

SCIENCE

109 No. 2825 Friday, February 18, 1949



AAAS EDITORIAL BOARD

(Terms expire July 31, 1949)

Arthur C. Bevan	Edward U. Condon
H. Bentley Glass	
Malcolm H. Soule	Everett S. Wallis
George A. Baitsell	
Editor-in-Chief	
Beth Wilson	
Executive Editor of Science	
F. A. Moulton, Advertising Representative	

CONTENTS

Rhythmic Behavior of the Nervous System: <i>Hudson Hoagland</i>	157
Polarization of Light From Distant Stars by Interstellar Medium: <i>W. A. Hiltner</i>	165
Observations of the Polarized Light From Stars: <i>John S. Hall</i>	166
Technical Papers	
Structural Control in the Formation of Gneisses and Metamorphic Rocks: <i>W. H. Newhouse, A. F. Hagner, and G. W. DeVore</i>	168
Rate of Nucleation of Solid Particles in a Subcooled Liquid: <i>J. C. Fisher, J. H. Hollomon, and D. Turnbull</i>	168
The Reduction of 2,3,5-Triphenyltetrazolium Chloride by <i>Penicillium chrysogenum</i> : <i>Rosalie Broun Fred and S. G. Knight</i>	169

Existence of a Tryptophan-Niacin Relationship in Corn: <i>Alvin Nason</i>	170
A New Method of Freezing Eggs in the Shell and Its Possibilities for Further Application on Freezing Foods in General: <i>Socrates A. Kaloyereas</i>	171
Reversal to Penicillin Sensitivity in a Cysteine-requiring Mutant of <i>Salmonella</i> : <i>H. H. Plough and Madelon R. Grimm</i>	173
Inhibition of Salt Accumulation in Excised Wheat Roots by 2,4-Dichlorophenoxyacetic Acid: <i>James F. Nance</i>	174

Comments and Communications

Directory of Latin-American Scientific Institutions; Direct-writing Instruments for Radio-cardiography; The Highest Laboratory in the World; A Suggested Contraction for "Desoxyribonucleic Acid"	177
---	-----

News and Notes	178
----------------------	-----

Science, a weekly journal founded in 1880, is published on Friday by the American Association for the Advancement of Science at the Business Press, 10 McGovern Ave., Lancaster, Pa. Editorial and Advertising Offices, 1515 Massachusetts Ave., N.W., Washington 5, D. C. Telephone, Executive 6060. Cable address, SCIMAG, Washington, D. C. Registered as second-class matter at the Post Office at Lancaster, Pa., January 13, 1948, under the Act of March 3, 1879. Accepted for mailing at the special rate postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, Section 538, P.L. and R., authorized January 13, 1948.

Manuscripts submitted for publication should be sent to the Editorial Office, with stamped, self-addressed envelope enclosed for possible return. The AAAS assumes no responsibility for the safety of the manuscripts or for the opinions expressed by contributors.

Annual subscription, \$7.50; single copies, \$.25; foreign postage, outside the Pan-American Union, \$1.00; Canadian

postage, \$.50. Remittances and orders for subscriptions and single copies should be sent to the Circulation Department, *Science*, 1515 Massachusetts Ave., N.W., Washington 5, D. C. Membership correspondence for the AAAS should be addressed to the Administrative Secretary at the same address.

Change of address. Four weeks' notice is required for change of address. This should be sent to *Science* Recorder, 1515 Massachusetts Ave., N.W., Washington 5, D. C. When ordering a change, it is necessary to furnish an address stencil label from a recent issue. Claims for a missing number will not be allowed if received more than 60 days from date of issue. No claims allowed from subscribers due to failure to notify the Circulation Department of a change of address or because an issue is missing from their files, or for any reason from subscribers in Central Europe, Asia, or the Pacific Islands (other than Hawaii).

The AAAS also publishes *The Scientific Monthly*. Subscription rates on request.

LIPPINCOTT SELECTED PROFESSIONAL BOOKS

Source Books in medicine

THE THYROID AND ITS DISEASES

by J. H. Means, M.D.

The new, fully revised, second edition of this authoritative work is made up of comparative case records covering the etiology, diagnosis, prognosis and treatment of thyroid diseases and disorders; the results of extensive studies by a distinguished specialist and his associates at the Thyroid Clinic of the Massachusetts General Hospital. *2nd Edition. 620 Pages. Illustrated. \$12.00*

Viral and Rickettsial Infections of Man, edited by Thomas M. Rivers, M.D. \$5.00

Bacterial and Mycotic Infections of Man, edited by René J. Dubos, M.D. \$5.00

Symposium on Medicolegal Problems, edited by Samuel Levinson, M.D., PH.D.

Volume I: Includes important contributions on Artificial Insemination—Operations to Produce Sterility, et al. \$5.00

Volume II: Includes Krogman on The Human Skeleton in Legal Medicine—Health Protection in Radioactive Research, et al. *In preparation.*

Uterine Contractility in Pregnancy, by Douglas P. Murphy, M.D., F.A.C.S. \$5.00

Congenital Malformations: A Study of Prenatal Characteristics with Special Reference to the Reproductive Process, by Douglas P. Murphy, M.D., F.A.C.S. \$5.00

Calcific Disease of the Aortic Valve, by Howard T. Karsner, M.D.
and Simon Koletsky, M.D. \$5.00



Lippincott Books

Philadelphia
London
Montreal

J. B. LIPPINCOTT COMPANY, East Washington Square, Philadelphia 5, Pennsylvania.

Please enter my order and send me:

- ☐ Means, *The Thyroid and Its Diseases*, \$12.00
☐ Rivers, *Viral and Rickettsial Infections of Man*, \$5.00
☐ Dubos, *Bacterial and Mycotic Infections of Man*, \$5.00

- ☐ Levinson, *Medicolegal Problems, Vol. I*, \$5.00
☐ Murphy, *Uterine Contractility in Pregnancy*, \$5.00
☐ Murphy, *Congenital Malformations*, \$5.00
☐ Karsner & Koletsky, *Calcific Disease of the Aortic Valve*, \$5.00

Name.....

☐ Cash enclosed

Address.....

☐ Send C.O.D.

City, Zone, State.....

☐ Charge my account

Rhythmic Behavior of the Nervous System

Walter D. Hoagland, *Executive Director,*

Forrester Foundation for Experimental Biology, Shrewsbury, Massachusetts

SINCE THE FAMOUS CONTROVERSY of Galvani and Volta in the last decade of the 18th Century, it has been known that living organisms generate electricity, and in 1848, when this Association was founded, many studies of the electrical properties of nerve and muscle had already been published. By that year, du Bois Reymond, for example, published a two-volume study of animal electricity, and in 1850 Helmholtz measured the rate of propagation of the nerve message for the first time and found it to be absurdly low for contact electrical action—of the order of 20 meters per second in frog nerve.

It is now established that all living cells are continuous converters of energy, and the form and function of the cell are maintained by dynamic steady states. Only dead cells are in thermodynamic equilibrium with their environments. Within each cell, catalyzed enzyme systems promote in stepwise sequences the degradation of foodstuffs that have entered the cell from its environment of body fluids, of sea water, or of fresh pond water, depending on its habitat.

Membranes separating the protoplasmic contents from the environment are selectively permeable. Due to the asymmetric steady-state flow of substances, including electrolytes, across cell walls, these walls are polarized so that, in most cells, the interior is found to be from 50 to 100 millivolts negative to the exterior. Cells store potential chemical energy, and because they are irritable, this energy can be converted suddenly to other forms. Thus a local decrease in the permeability of a cell membrane, initiated by electrical, chemical, mechanical, or thermal means, permits the cell's own currents to flow through this region of changed permeability from the positively charged outside to the more negatively charged inside and to complete the circuit by flowing back out more diffusely through the adjacent intact membrane. Such a local current in itself may act as an electrical stimulus to release energy from adjacent areas of the cell, so that a wave of electrochemical change is propagated away from the stimulated region as swirling eddies of inwardly and outwardly directed current. In long filamentous cells, such as nerve fibers, the passage of such impulses is detectable with recording apparatus.

WAVES OF ACTION IN NERVE TISSUE

Any study of the behavior of nerve mechanisms becomes a study of waves and rhythms. The impulses in

afferent nerve fibers that convey information to the brain and the signals sent out by the brain over motor nerve fibers to muscles are waves of electrochemical change that sweep along the fibers at speeds ranging from a fraction of a meter per second in very small fibers to 120 meters per second in large fibers. Accompanying the passage of impulses in nerve are definite electrical, chemical, and thermal changes.

During the first two decades of this century, primarily through the work of Gotch and of Lucas, it was learned that nerve impulses travel as discrete pulses of energy, and following each pulse or wave, the nerve is refractory to further stimulation for very brief intervals of the order of milliseconds or fractions thereof. Time is required for membrane excitability to be restored by metabolism.

The accelerating development of good electronic devices by physicists and engineers since the middle 1920's has yielded much information about impulses in individual sensory and motor nerve fibers and the ways in which sensory nerves transmit information from the environment to the brain. Adrian and a number of other physiologists have shown that intensity of sensation and strength of muscular contraction are correlated with frequency of nerve impulses, but quality or modality of sensation is not traceable to peripheral nerve impulses but is rather a central phenomenon of the brain.

Impulse conduction across junctions between nerve cells, called synapses, takes place in only one direction. While nonsynaptic nerve nets exist in lower animal forms, such as coelenterates, well-integrated and complex behavior requires effective switching devices as represented by the one-way synapse, where temporal and spatial summation of impulses takes place, permitting control and direction of excitation and inhibition of contiguous cell units.

The nature of waves of action in nerve tissue was well described by A. V. Hill (7) in 1933, when he wrote:

“Most of the well-known oscillations with which physics is concerned are a consequence of the reaction with one another of properties analogous to inertia and elasticity. A moving or a changing system tends, on the one hand, to continue in its state of motion because it possesses, for example, mass or inductance; even social, economic and intellectual changes are endowed with such characters of inertia which keep them going when they have passed a true position of equilibrium. On the other hand, such

systems, if they are to continue to exist, if they are not merely to be dissipated, must possess converse properties which tend to bring them back once they have overshot their equilibrium: such properties in physics are elasticity and electrical capacity; in finance and politics, fear and conservatism. These exercise a constraining force increasing with the displacement from equilibrium, and ultimately reverse the motion or change and the same oscillation is repeated in the opposite direction.

"There is, however, another type of oscillation, less commonly discussed in physics and mechanics but nonetheless well-known in everyday affairs; that which depends upon a discharge taking place when some limiting potential or intensity is reached. For example, water falling into a tank equipped with a syphon will come out in rushes whenever it rises to a certain level. Or again, a population in which an epidemic of measles cannot start because of the number of people in it who are immune, having had the disease already, will gradually become less immune as time goes on, and finally an epidemic, a wave of measles, will sweep through it. A neon lamp with a parallel condenser in series with a resistance and an electromotive force, will discharge at regular intervals, namely whenever the potential difference across the condenser reaches a certain critical value. This type of oscillation does not depend upon inertia reacting with elasticity. Its essential nature is that (a) some state, some potential, some intensity, is built up by a continuous process, and the condition becomes less and less stable until one is reached in which discharge must take place, and (b) this discharge, once started, forms a path for itself by which (as in a syphon or an electric arc) further discharge is facilitated until what has been built up gradually has been broken down and the process begins again. This type of oscillator (sometimes referred to as a relaxation oscillator) is the one with which we are concerned in physiology.

"Waves may be transmitted on the same principle in a system extended in space. An unstable state is gradually built up at some point, either through an external agency or by some intrinsic process, discharge is begun which starts and facilitates a discharge in neighboring regions which themselves discharge, and so a wave is propagated. Such waves will occur periodically if at some region the potential at which discharge begins is less than that finally attained by the continuous process of charging. They will require, however, an external agency (a 'stimulus') to start them if the unstable condition, the limiting potential, is not attained spontaneously. Models of such waves will occur to all of you; their principle is obvious. I have emphasized it because the waves on which nervous activity is based appear to be of this type. All detailed theories of nervous transmission may well be wrong but this general idea of it, involving a building up and discharge, is almost certainly right."

All human behavior, whether it be a reflex response to stepping on a tack or the development of a mathematical analysis, depends finally on the organization of messages in the central nervous system. As Jo-

hannes Müller stated over a century ago, we do not sense a direct external world but rather properties of this world as interpreted by our nervous system. Since all nerve messages in individual nerve fibers are alike except for differences in timing and voltage, this means that patterns of organization of messages in the brain must be the ultimate basis for the quality of our experience, including ideas themselves.

ELECTRICAL BRAIN WAVES

In 1929, Hans Berger reported sinusoidal electrical oscillations of a frequency of about 10 per second picked up from electrodes attached to the scalp of relaxed human subjects with closed eyes. Berger's important observations were soon confirmed and in the past 18 years hundreds of studies of electrical activity of the brain, animal and human, have appeared.

The electroencephalogram, or EEG, as the brain wave record is called, usually displays a dominant

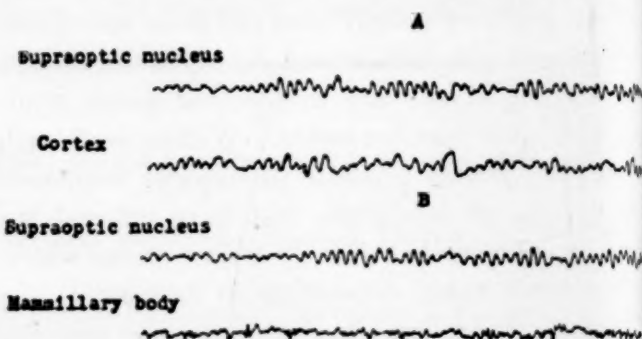


FIG. 1. Two pairs of records from an unanesthetized dog with small leads inserted in the brain. A—Upper from anterior hypothalamus; lower from cortex (simultaneous recording). The dominant rhythms are 14 per sec. B—Upper from anterior hypothalamus; lower from mammillary body (simultaneous recording). From Hoagland, Himwich, Campbell, Fazekas, and Hadidian, *J. Neurophysiol.* 1939, 2, 276.

frequency called the alpha rhythm of 9 to 11 cycles per second at an amplitude of 20 to 50 microvolts, most conspicuous from the occipital region of the head over the region of the brain concerned with visual processes, although it is often manifest all over the head. Exploration of nuclei and tracts in exposed brains of living animals and of man at operation show that all of the brain centers are rhythmically active at frequencies of 2 to 30 cycles per second, with different frequencies characteristic of different nuclei but with predominant activity in the range of 8 to 18 cycles per second. Fig. 1, for example, shows cortical and hypothalamic records taken by us from an unanesthetized and contented dog with small electrodes permanently imbedded in the cortex and in the hypothalamus. The cortical records and the records from the anterior hypothalamus show the same type of waves, although the activity from the posterior hypothalamus displays faster and more irregular

quencies. Fig. 2 shows pairs of EEG tracings from each of 5 persons. The upper trace of each pair is from the occipital cortex and the lower trace is from a lead at the roof of the pharynx near the anterior hypothalamus. Somewhat different brain wave patterns characterize each individual, but it is interesting to note the similarity of the records from two such remote brain areas in the same person.

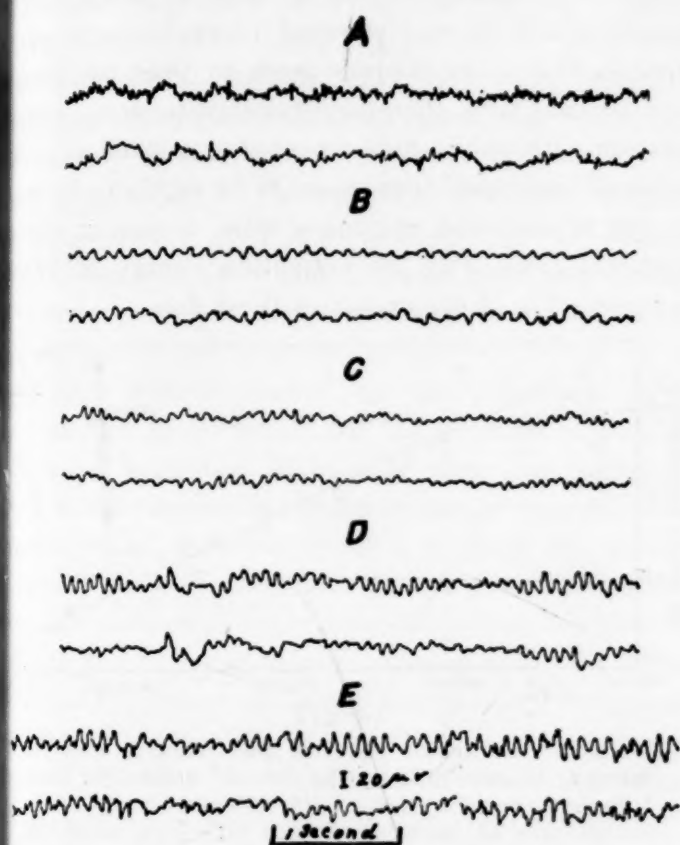


Fig. 2. Pairs of electroencephalographic tracings from five persons. A, B, C, D, and E refer to different individuals. The upper tracing of each pair is from a cortical electroencephalogram, and the lower tracing of each pair is from a recording made simultaneously with a lead inserted in the roof of the pharynx near the anterior hypothalamus. The upper tracings of A, B, and D are from the vertex. The upper tracings of C and E are from the occiput. Note similarities of patterns in a given individual from cortical and basal leads. From Hoagland, Cameron, Rubin, and Tegelberg, *J. gen. Psychol.*, 1938, 19, 247.

sinusoidal pattern appears to be due to the distribution of thresholds of firing of groups of cells. Evidence indicates that reverberating circuits of activity, involving one-way cell-to-cell synaptic conduction between thalamus and cortex and back again, and even between hypothalamus, thalamus and cortex, are involved in the rhythms, since suitably placed lesions in these lower centers may abolish some of the cortical rhythms, apparently by interrupting loops of neurone-to-neurone conduction. But, on the other hand, conduction can take place from cell to cell in oriented

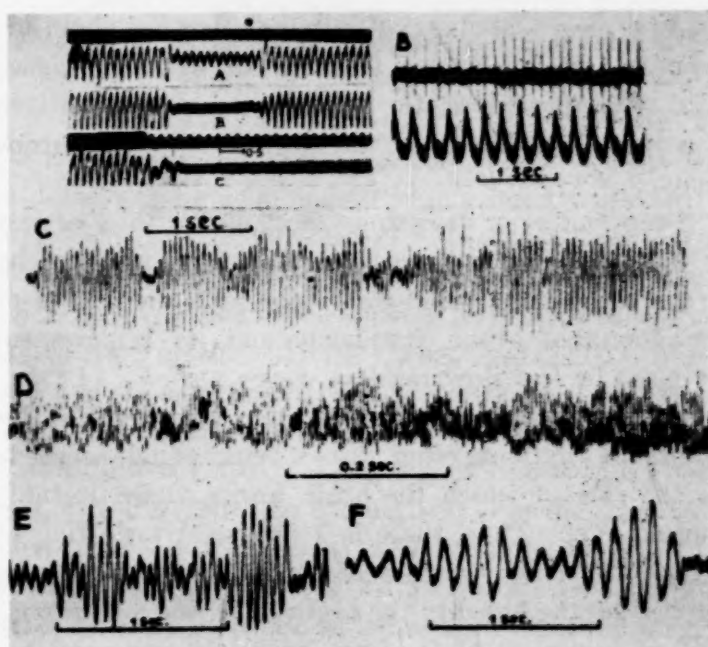


Fig. 3. Waves and rhythms from different central nervous systems as figured by F. Bremer (*J. belge Neurol. Psychiat.*, 1947, 47, 542). A—Optic ganglion of the beetle *Dystiscus*: effect of light of increasing intensity (A through C) in abolishing the rhythm (from Adrian, 1937). B—Catenary ganglion of the lobster: ganglionic waves (below) and nerve impulses led from an interconnecting nerve trunk (from Bonnet, 1938). C—Gray substance of the anterior horn of the cat spinal cord discharging synchronously after a period of asphyxia (from Bremer, 1941). D—Cat cerebellar cortex: synchronous activity following brief electrical stimulation (from Dow, 1937). E and F—Rhythmic activity in two functional states of the cerebral cortex of the cat after surgical de-afferentiation (from Bremer).

polarized brain cell layers by electrotonic action from active to inactive cells by way of electrical conduction through bathing fluids and independent of synaptic circuits. This phenomenon has been demonstrated by studies from the laboratory of F. Bremer (2, 3) of Brussels and in this country by Gerard et al. (5) in studies of electrical waves in frog brain and in isolated pieces of frog brain. Moreover, in lobotomy operations, cutting connections of the frontal lobe of the cortex with the thalamus in man does not modify the frontal brain wave patterns. Thus, both synaptic conduction and nonsynaptic electrotonic conduction appear to be involved in the spread of brain waves in

While the EEG is generally characterized by a dominant frequency of around 10 cycles per second, Fourier transforms make it clear that a whole spectrum of waves ranging from 2 to 30 cycles per second is present from any given locus. There is considerable variation in the dominance of components of the frequencies from person to person and studies of identical twins and of family groups in general show a strong tendency for the particular EEG patterns to be inherited. This is also true of abnormal patterns that have proved useful in diagnosing epilepsies.

The brain waves are composed of electrical discharges of many cells firing in synchrony and the

central nerve tissue, and work of a number of investigators has shown basic brain wave rhythms to be independent of the arrival of afferent impulses, although such impulses can modify the rhythms. Fig. 3, from a paper of Bremer (2), illustrates brain wave rhythms of central nervous tissue from beetles to mammals.

A variety of factors have been found to change the EEG patterns. Thus, the alpha rhythm is characteristic of the subject at rest with eyes closed. Pattern vision with the eyes opened, i.e., focusing visual attention, and even the recall of visual images with the eyes closed, abolishes it although it is not abolished even by strong diffuse illumination through closed lids. Occupation of the visual cortex with pattern discrimination disrupts the synchronized neurone beats.

Sleep and even drowsiness, together with a variety of conditions of impaired consciousness produced by drugs, are accompanied by slowing and disruption of the dominant alpha frequency and its replacement by more or less slow random waves.

One factor determining the basic frequency of the dominant rhythms, other things being equal, seems to be the rate at which the brain burns sugar, its only normal fuel. Thus, there is a progressive slowing of alpha frequency with decreasing sugar or oxygen carried by the blood to the brain or by the administration of inhibitors of the brain's oxidative enzyme systems; conversely, metabolic stimulants increase the frequency. Increasing the alkalinity of the blood slows the frequencies, an effect which is easily demonstrable by rapid deep breathing that blows off carbon dioxide.

Increasing the internal body temperature by fever or by diathermy increases alpha brain wave frequencies and some years ago we found that the Arrhenius equation relating the rates of pace-limiting simple chemical processes to temperature describes this relationship, and gives three values for the activation energy. Two of those values are identified with specific enzyme systems which are known to be present in the brain and which appear to act in the brain's sequence of oxidation steps as rate-limiting chemical pacemakers for the alpha frequencies (6, 8).

These metabolic findings are consistent with the view expressed by Hill in our earlier quotation; namely, that nerve cells function as relaxation oscillators that may fire repetitively in response to voltages built up across the cell's membranes by cellular oxidation. This general point of view applies equally well whether the cells are regarded as firing as independent units stimulating neighboring cells to synchrony by electrotonic action or whether the brain

waves are due to synchronized reverberating circuits involving, by synaptic conduction, extensive brain regions in loops of activity.

It is of interest in this connection that we have found the human time sense to obey the Arrhenius equation and yield an activation energy similar to that encountered in some studies of cell respiration but different from that for alpha frequencies. The subjective counting of the number of seconds in a minute speeds up with elevated internal body temperature so that more seconds seem to pass per minute and private time therefore appears to drag in comparison with public time accepted as a standard. Our sense of time itself thus seems to be regulated by some as yet unidentified enzyme system, a sort of master chemical clock with an activation energy of 24,000 calories. Fig. 4 demonstrates these data.

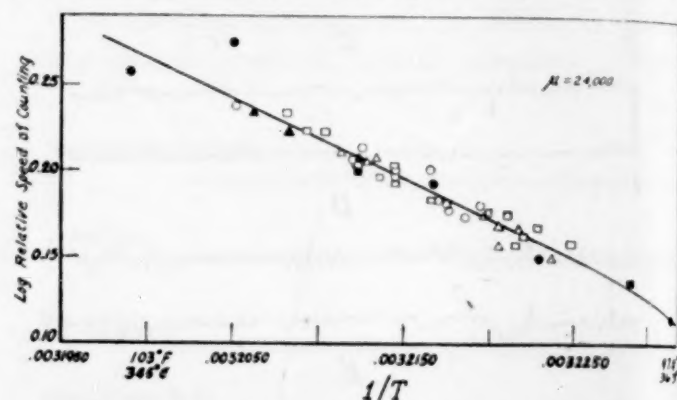


Fig. 4. Arrhenius equation plot showing effect of internal temperature on the rate of estimating time. Different symbols refer to different persons. The absolute rate of counting is not indicated, since the ordinate has been telescoped. From Hoagland, *J. gen. Psychol.*, 1933, 9, 269.

On the clinical side, during the past 15 years electroencephalography has proved to be an important adjunct in diagnosis of epilepsy and in localizing brain lesions for subsequent surgery.

BRAIN PHYSIOLOGY AND BEHAVIOR

The discovery of continuous rhythmical electrical activity in the brain has opened new possibilities of interpreting the physiological basis of behavior. Mental processes have a continuity, and consciousness is an enduring affair interrupted at intervals by the sleep rhythm but otherwise normally persisting throughout life. Nothing in the study of classical reflex mechanisms has adequately accounted for learning and the persistence of memory. For a century after Magendie and Bell, the brain was regarded as a complex system of pathways whereby impulses from the periphery reached effector organs to produce behavior in stimulus-response sequences and, while many excellent studies of spinal reflexes shed light on the physiology of these fundamental units of behavior, little progress

in correlating brain physiology with higher mental processes was possible so long as the brain was regarded merely as a classical passive telephone-switchboard. Who, after all, plugged in the right connections? Who or what was the operator of this inert switching system? Obviously the brain itself—but how?

Since 1943 several contributions have appeared which shed suggestive light on this problem. Thus, Rosenblueth, Wiener, and Bigelow (11); Pitts and McCulloch (10); Adrian (1); and more recently Northrop (9) have considered these matters from refreshingly new angles. It has been my privilege to read in manuscript Norbert Wiener's book *Cybernetics, or control and communication in the animal and the machine* (13) and I should now like briefly to consider a few of the matters pertinent to waves and rhythms raised in these studies.

In 1940 Wiener worked out the principles of a machine now in operation for the solution of partial differential equations with more than one variable, and has made interesting comparisons of this machine with the brain. Kenneth Craik in his book *The nature of explanation* (4) has made similar comparisons but Wiener's analysis is more extensive. The machine is fed data and proceeds to perform a complicated series of logical operations at a rapid rate through electronic switching devices. The computations are based on a scale of two after the algorithms of Boolean algebra rather than on a scale of ten, and electronic relays which give an on-off or a yes-no answer are the switching devices employed.

All data according to the rules of logic and number are operated upon by the machine in sets of choices between two alternatives, and all the operations on the data take the form of making a set of new choices dependent on a set of earlier choices. The operations are timed by a central clocking device. This clocking may be performed by an actual clock, or its equivalent may be performed by not permitting a process to take place until its antecedents have occurred.

No human interference with the processes takes place from the time of supplying the machine with its initial information until the end of the calculations. Thousands of ordered operations take place at an exceedingly rapid rate, condensing into minutes processes that would require days to complete with ordinary methods of computation.

In such a machine there are devices to retain impulses until it is time for the appropriate circuit to act and relate them to other events in the processes of computation. This may be done in the machine by systems of reverberating circuits and by electronic scanning devices, such as are used in television and

also in the form of magnetization patterns of the molecules in iron wire after the manner of the well-known wire recorder. Thus, information can be stored until ready for use, and the machine quite literally possesses a functional memory in the form of patterns of dynamic electrical configurations or of molecular patterns which may be called upon to furnish information by appropriate stimuli arriving as timed pulses from other circuits in the apparatus. It is important to realize that this memory need not be lodged in any one locus in the machine, but belongs to its function as a whole. To ignore this is to commit the fallacy of Descartes in locating the action of mind on matter in the pineal gland.

A basic controlling principle in the integration of patterns of activity in the machine is that of negative feed-back, and evidence clearly indicates that negative feed-back plays a fundamental role in nervous integration. In any system displaying negative feed-back, some of the output of the system returns to limit and control its further output. Thus, Rosenblueth, Wiener, and Bigelow point out that negative feed-back means the behavior of an object is controlled by the margin of error at which the object stands at a given time with reference to a relatively specific goal. A robot-controlled plane may, for example, be directed automatically to seek its target by electromagnetic waves sent out by it and reflected back from the target so as to modify the steering mechanism. The proximity fuse detonates the shell as it approaches the target by the return of electromagnetic waves broadcast from the shell and reflected back to it. Again, the thermostatically controlled house heating system is a more prosaic example of negative feed-back, since as the temperature rises it shuts off the heater and when the house cools off the furnace is turned on again by the thermostat. Engine governors and the steering engines of ships furnish other examples of negative feed-back, and mechanisms so controlled are called servomechanisms.

Nervous system processes are replete with examples of negative feed-back. Thus increasing blood pressure excites stretch receptors in the carotid sinus, which sends to the vasomotor center impulses causing a fall in blood pressure. Homeostatic mechanisms in general that regulate our internal environment use principles of negative feed-back. Breathing movements are examples of control of rhythms of inspiration and expiration by negative feed-back. Another example is the control of movements of the limbs by reciprocal inhibition of antagonistic muscles, producing orderly movement, and Adrian in his *Physical background of perception* (1) has discussed a number of such mechanisms familiar to neurophysiologists. The cerebel-

lum is a complex coordinating center for smoothly controlling by way of negative feed-back sensory impulses from the limbs essential to precisely coordinated movements.

Lorente de Nó has demonstrated the action of what he calls reverberating chains of neurones so arranged in closed paths in the central nervous system that each neurone excites the next around the loop, the last finally reexciting the first. With 10 billion neurones in the human central nervous system an appalling number of interacting neurone loops are possible. Action once started in such reverberating circuits can continue indefinitely as long as metabolism supplies the requisite energy.

Suppose now that one or more of the neurones in such a loop is fired by a specific sensory impulse. This loop involving many neurones will correspond to the physiological substratum of that specific sensory event and as McCulloch has put it "A train of impulses in a regenerative loop preserves the form of the fact without reference to the one particular moment when it was experienced." Comparable loops of activity are stored in the electronic calculating machine by use of reverberating systems and principles of electronic scanning.

Wiener also points out that the neurone operates on an on-off basis like an electronic relay. It either fires or not, and the parallel to the machine and its binary scale of operation is thus further borne out in terms of the basic units comprising the brain and the machine. Changing the grid bias of tubes by automatic devices modifies the tube's timing and in like manner negative and positive after-potentials of neurones are important in regulating impulse passage at synapses through modifications of synaptic excitability.

Voluntary acts by their very nature exemplify negative feed-back. Thus when we proceed to pick up an object from a table we do not command a specific sequence of muscular acts. Rather, as Wiener suggests, the controlling factor in the act is the degree to which the act has not been completed. The object may be picked up with either the right or left hand or even by the mouth if the hands are tied. The action ceases when the purpose is realized, after the manner in which servomechanisms control actions and bring them to a stop. Servomechanisms are purposive in nature.

Rosenbluth and Wiener are preparing for publication an experimental study of muscle clonus in spinal and in decerebrate cats. From an analysis of the clonus frequency based on the theory of servomechanisms, they found good preliminary agreement between calculated and experimental values of the

muscle's rhythm of contraction in response to stimulation of its myotatic receptors by stretch.

FORM PERCEPTION AND MEMORY

Pitts and McCulloch (10) published a paper entitled: "How we know universals, the perception of auditory and visual forms." In this paper they present both anatomical diagrams based on cortical neuro-anatomy and a mathematical analysis indicating how a scanning mechanism consisting of waves of impulses sweeping up and down over interlacing nonspecific and associative afferent fibers in the cortex can furnish a basis for the perception and recognition of form when specific afferent stimuli arrive over sensory pathways. In this type of nerve network, form, whether that of a musical chord or a geometrical pattern, is independent of size or position in the field and it is independent of any particular neurone or small neurone group. In this connection it is interesting to recall that Lashley found recognition of patterns and retention of learned acts in rats to be affected to a surprisingly small degree by the surgical removal of specific anatomical brain areas. Retention of learned acts seemed to depend more upon the amount of tissue left than on its locus.

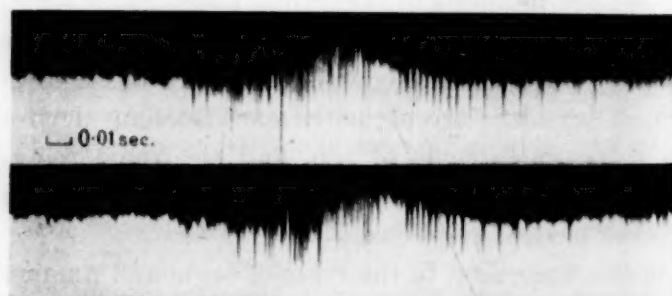


Fig. 5. Complex discharges in several units of the cerebral cortex following the local application of strychnine. Both outbursts are due to sensory stimulation (touching the foot) and show the tendency for the cortex to repeat the same pattern of discharge. From Adrian and Moruzzi, *J. Physiol.*, 1939, 97, 153.

Pitts and McCulloch write "It is to the nonspecific afferents that modern physiology attributes the well-known rhythmic sweep of a sheet of negativity up and down through the cortex—the alpha rhythm. If our model fits the facts this alpha rhythm performs a temporal 'scanning' of the cortex which thereby gains, at the cost of time, the equivalent of another spatial dimension."

Lashley's experiments with rats indicate that memory traces occupy very extensive cortical areas, since the ablation or transection of a given region does not destroy memory, and he has suggested that signals reaching receiving areas of the cortex may reverberate extensively, affecting patterns of action in innumerable rhythmically acting local circuits. Memory

traces would then be more or less stable resonance patterns which might be extensively reduplicated all over the cortex, ready to respond to incoming signals which fitted the pattern of response. Fig. 5, from a paper of Adrian and Moruzzi, shows such a pattern at one point on the cortex set up in response to a specific sensory stimulation of the foot.

But, as Adrian (1) has pointed out, it is difficult to see how memories can survive great changes in the over-all patterns of activity of the brain such as occur in normal sleep or in anaesthesia. As Adrian has stated in his lectures on the "Physical Background of Perception," "Clearly if memory traces are patterns they must tend to occur in the same form after a period of inactivity and to bring this about it seems to be necessary to postulate some semipermanent modification as well. A slight change in the exceedingly plastic structure of nerve cells and dendrites would be enough [following activity]." In this connection I would like to suggest by analogy that the storage of information in the wire recorder modifies the wire at a molecular level but not within optically observable microscopic dimensions and information fed by such a wire to scanning circuits can reappear in its original form after a shutdown of the apparatus when its circuits are later reactivated.

Finally, it is worth recalling that both the brain and the machine operate in relation to internal master clocks. In the case of the brain, steady-state enzyme kinetics appear to regulate our time sense.

PHILOSOPHICAL IMPLICATIONS

Northrop, in a paper entitled "The Neurological and Behavioristic Psychological Basis of the Ordering of Society by Means of Ideas" (9), has discussed the work of Wiener, Rosenbluth, McCulloch and Pitts against the background of two opposing philosophical views of the role of ideas as determinants of behavior. To the Lockian and Cartesian dualists and to the idealistic German philosophers there are only mechanical causes and no purposes or universals in the biological realm, only particular events and no remembered events with their persistent meanings. According to these classical views, purpose, memory, and the existence of universals establish the reality of nonbiological minds or mental substances and thus lead to the formulation of vitalistic theories. Opposing these views have been the mechanistic biologists and the behavioristic psychologists for whom purpose and mind are mere appearances or epiphenomena, and only stimuli and observed responses are real. Ideas as determinative causes are regarded as mere rationalizations after the fact of behavior.

Northrop dismisses both of these points of view in

terms of the light shed by the recent neurophysiological concepts, pointing out that purposeful goal-directed behavior is possible in human neurological

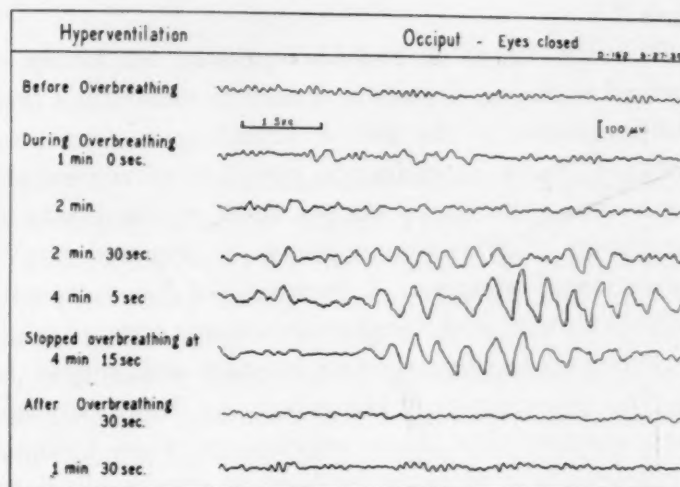


Fig. 6. Effects of hyperventilation on the human electroencephalogram. Note marked slowing accompanying the excessive removal of CO_2 by overbreathing. From Davis and Davis, Res. Publ. Ass. nerv. ment. Dis., 1939, 19, 50.

systems containing negative feed-back mechanisms and patterns of reverberating circuits which are the epistemic correlates of ideas and which can function causally. Signals from the goal can alter behavior after it has been initiated so that it reaches the goal. This is the requirement for any mechanism in order that it be goal-directed and "a teleological system can

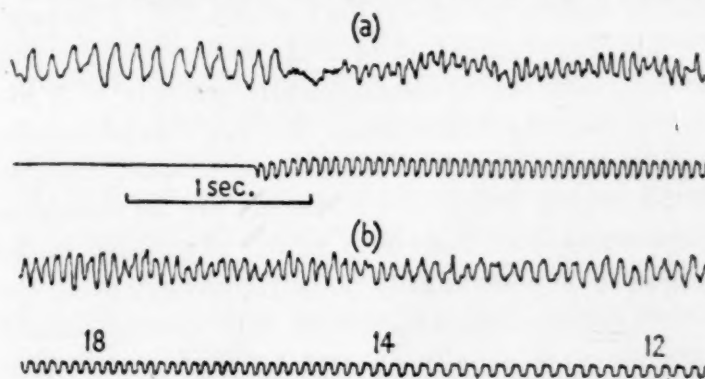


Fig. 7. Records from the occipital region of the head, showing the effect of flickering light. Below the records from the head are tracings from a photoelectric cell indicating the rate of flicker. In the lower record the rate was reduced from 18 to 12 per sec, and the cerebral waves keep in step with the flicker. The cerebral waves are potential changes of the order of 20-30 microvolts. Adrian reports that the alpha frequency here driven at 18 per sec can be driven up to 30 per sec by flickering light. From Adrian, *Lancet*, 10 July, 1943, p. 34.

be—and in the human nervous system it is—a mechanical system. It is a mechanical system in which the behavior of the system is controlled by a negative feed-back over the goal.

"Because overt behavior can be tripped by impulses from reverberating circuits whose activity conforms

to universals as well as by impulses coming immediately from an external particular event, the behavior of men can be, and causally is, determined by embodiments of ideas as well as by particular environmental facts."

If brain waves do indeed represent the sweep of cortical scanning circuits it is easy to understand their disappearance in the act of attending to visual experience. Thus attending to sights or even recollecting visual experiences causes them to disappear as the sweep of television scansion is obscured by the formation of pictures. Asynchrony of the nonspecific sweep afferents with the specific sensory circuits might be expected to obscure consciousness and indeed we do find consciousness lost when the brain rhythms show random slow wave activity, or when epileptic discharges take place in the form of abnormally large synchronized bursts of activity. However, it is nonetheless possible to modify profoundly the alpha frequency without appreciable effect on perception or coordinated behavior. This fact is hard to reconcile with the need for precise synchrony of specific afferent patterns of continuous circuits as epistemic correlates of ideas and sweep frequencies of scanning circuits. Thus, hyperventilation can slow the dominant brain wave frequency from 10 cycles per second to 3 and on the other hand flickering light can increase its frequency from 10 to 30 per second without observable modifications of memory, consciousness or of perception in healthy persons (Figs. 6 and 7). However, it is also interesting that both of these procedures can produce seizures in some epileptic patients with attendant loss of consciousness. We might expect modification in the sweep of scansion to produce changes of this kind in everyone, but changes are the exception and not the rule. Failure to modify perception would appear to be possible only if the frequencies of all the reverberating circuits concerned with specific sensory afferents were equally affected by the agents affecting the scanning frequency of the nonspecific associative afferents. But it is hard to see how such uniform synchrony would be possible over wide association areas of the brain, many of which experimentally show different thresholds of susceptibility to chemical

agents and which may not be appreciably affected by a stimulus such as a flickering light that drives the neurones concerned with visual reception.

The hypotheses of Wiener and his colleagues are highly suggestive. It will be interesting to observe their impact on experimental physiology during the next decade.

It would be agreed, I am sure, that one of the most significant physiologists of our time is Sir Charles Sherrington and a quotation from his book *Man: on his nature* (12) is an appropriate conclusion to a paper on waves and rhythms in the nervous system. In language of singular charm, it pictures the brain asleep and awake. Imagine

"A scheme of lines and nodal points, gathered together at one end into a great ravelled knot, the brain, and at the other trailing off to a sort of stalk, the spinal cord. Imagine activity in this shown by little points of light. Of these some stationary flash rhythmically, faster or slower. Other are travelling points streaming in serial lines at various speeds. The rhythmic stationary lights lie at the nodes. The nodes are both goals whither converge, and junctions whence diverge, the lines of travelling lights. Suppose we choose the hour of deep sleep. Then only in some sparse and out-of-the-way places are nodes flashing and trains of light points running. The great knotted headpiece lies for the most part quite dark. Occasionally at places in it lighted points flash or move but soon subside.

"Should we continue to watch the scheme we should observe after a time an impressive change which suddenly accrues. In the great head end which had been mostly darkness spring myriads of lights, as though activity from one of these local places suddenly spread far and wide. The great topmost sheet of the mass, where hardly a light had twinkled or moved becomes now a sparkling field of rhythmic flashing points with trains of travelling sparks hurrying hither and thither. It is as if the milky way entered upon some cosmic dance. Swiftly the head mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one. The brain is waking and with it the mind is returning."

Based on an address given at the Symposium on Waves and Rhythms held on September 16, 1948 in Washington, on the occasion of the Centennial Celebration of the American Association for the Advancement of Science.

References

1. ADRIAN, E. D. *The physical background of perception*. New York: Oxford Univ. Press, 1947.
2. BREMER, F. J. *Belge Neurol. Psychiat.*, 1947, **47**, 542.
3. BREMER, F. *Arch. Neerl. Physiol.*, 1944-1947, **28**, 481.
4. CRAIK, K. J. W. *The nature of explanation*. Cambridge, Engl.: at the Univ. Press, 1947.
5. GERARD, R. W. *J. Neurophysiol.*, 1941, **4**, 438.
6. HADIDIAN, Z., and HOAGLAND, H. *J. gen. Physiol.*, 1939, **23**, 81.
7. HILL, A. V. *Cold Spr. Harb. Sympos. quant. Biol.*, 1933, **1**, 146.
8. HOAGLAND, H. *Amer. J. Physiol.*, 1936, **116**, 604.
9. NORTHROP, F. S. C. *Science*, 1948, **107**, 411.
10. PITTS, W., and MCCULLOCH, W. S. *Bull. math. Biophys.*, 1947, **9**, 127.
11. ROSENBLUTH, A., WIENER, N., and BIGELOW, J. *Phil. Sci.*, 1943, **10**, 18.
12. SHERRINGTON, C. S. *Man: on his nature*. New York: Macmillan; Cambridge, Engl.: at the Univ. Press, 1941.
13. WIENER, N. *Cybernetics, or control and communication in the animal and the machine*. New York: John Wiley; Paris: Hermann et Cie, 1948.

Polarization of Light From Distant Stars by Interstellar Medium

W. A. Hiltner

Yerkes Observatory, University of Chicago

IN THE COURSE OF PHOTOELECTRIC OBSERVATIONS made last summer with the 82-inch telescope of the McDonald Observatory (University of Texas) the writer found that the light from distant galactic stars is polarized. Polarizations as high as 12 percent were found. The plane of polarization appears to be close to the galactic plane in the cases examined. More recently control measures were made at the Lick Observatory, thanks to the courtesy of Director Shane and Dr. G. Kron; and during December the work at the McDonald Observatory was extended to different regions of the Milky Way.

In view of the unexpected nature of this result the circumstances leading to its discovery are recorded. Photometric observations for the detection of partially polarized radiation from eclipsing binary stars have been in progress at the Yerkes Observatory for several years with a view to establishing observationally the effect pointed out by Chandrasekhar that the continuous radiation of early-type stars should be polarized (1, 2). On the assumption that the opacity of early-type stars is due to scattering by electrons, the continuous radiation emerging from a star should be polarized with a maximum of polarization of 11 percent at the limb. Since the presence of this polarization can be detected only when the early-type star is partially eclipsed by a larger-type companion of the system, the effect is masked by radiation from this companion so that the expected maximum observable effect was only of the order of 1.2 percent in one case investigated (RY Persei).

At this stage Dr. John Hall, of Amherst College, proposed to the writer a program of collaboration whereby Dr. Hall would construct a "flicker" photometer which was to be tested jointly at the McDonald Observatory. Independently the writer was developing his own equipment which used polaroids. Dr. Hall's equipment was tested in August 1947, during a short session at the McDonald Observatory, but no dependable results were obtained and it was found that the equipment had to be remodeled. Unfortu-

nately, Dr. Hall was unable to come for a second trial period, scheduled for August 1948.

Meanwhile the writer's own equipment was completed and put to use during the summer of 1948 and was found satisfactory. Certain Wolf Rayet stars which were known or suspected to be eclipsing binaries were examined for polarization. Fairly large polarizations were found, but *they did not appear to depend on the phase of the binary motion*. The possibility of instrumental polarization was considered, of course, but ruled out by control measures on check stars. The Wolf Rayet stars give the following results:

Star	Polarization	
	%	Position angle
CQ Cep	10.0	62°
BD 55°2721	8.0	44
WN Anon*	12.5	44

*Coordinates: $22^{\text{h}}08^{\text{m}} + 57^{\circ}26'$ (1945); 12.5 magnitude.

The control stars had similar color and brightness, but showed no polarization except for one object, BD 55°2723, which gave 3 percent. This star, however, is a giant and more distant than the other control stars. Similar observations made on a group of Wolf Rayet stars in Cygnus showed no appreciable polarization, while two stars in Scutum gave positive results. Other regions, such as the double cluster in Perseus, also show polarization with values ranging up to 12 percent.

We conclude from the positive and negative results quoted that the measured polarization does not arise in the atmospheres of these stars but must have been introduced by the intervening interstellar medium. If this conclusion is accepted, a new factor in the study of interstellar clouds is introduced. Further observations are in progress for relating this phenomenon with other observable characteristics of interstellar medium. As has been stated, the results already at hand indicate that the plane of polarization approximates the plane of the galaxy.

References

1. CHANDRASEKHAR, S. *Astrophys. J.*, 1946, **103**, 365.
2. HILTNER, W. A. *Astrophys. J.*, 1947, **106**, 231.

Observations of the Polarized Light From Stars

John S. Hall

U. S. Naval Observatory, Washington, D. C.

PHOTOELECTRIC OBSERVATIONS of the polarization of starlight made during the period November 1948 to January 1949 with the 40-inch reflector at Washington substantiate the hypothesis of W. A. Hiltner (2) that this effect is produced by interstellar matter. Furthermore, the percentage of polarization appears to be independent of wavelength; and the plane of polarization (plane containing the magnetic vector and the line of sight) appears to have no one preferential orientation.

The observations were obtained with a photoelectric polarizing photometer (1) built at Amherst College

stars showing large and small percentages of polarized light are shown in Figs. 1 and 2. The vertical lines represent two-minute intervals. The trace during interval *S* is produced by polarized light from the star. During interval *D* a quartz depolarizer is placed in the light path, and *C* is the result when the cover glass is tilted 20° about an axis whose position angle is arbitrarily set at 94° . The starlight was already depolarized during the interval *C*. The plane of polarization is defined by the direction of the light and the axis about which the glass is tilted. A 20° tilt corresponds to 1.4% polarization.

The percentages of polarization of the light from 27 early-type stars are shown in Fig. 3 as a function of the color excesses determined by Stebbins and Huffer (3). A strong correlation is obvious; the

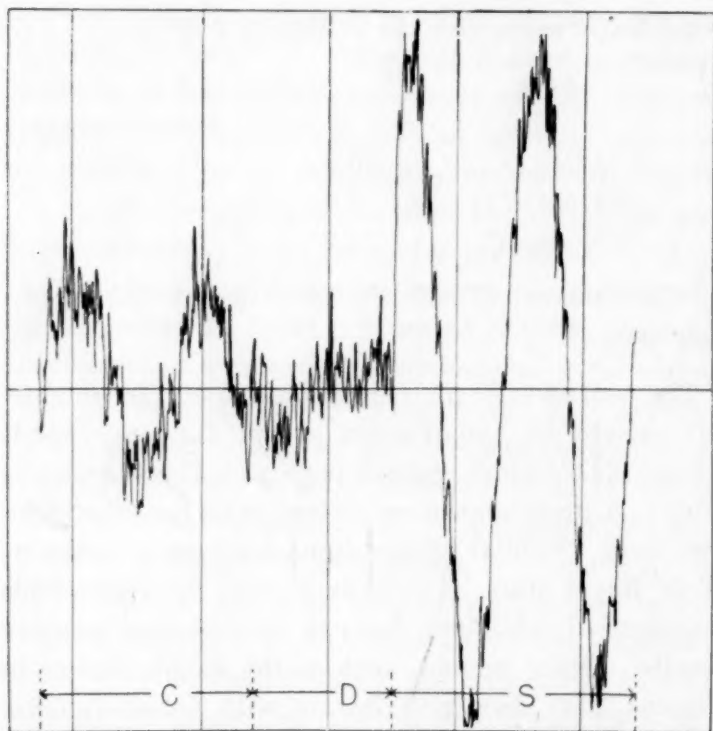


FIG. 1. Star HD 19820, a reddened star of spectral type O8. Polarization, 5.0%; position angle of the plane of polarization, $+30^\circ$.

in 1946 with the aid of a grant from the Research Corporation of New York. The light from a star is collimated and directed through a cover glass, which serves as a calibrating device, and then through a Glan-Thompson prism rotated at 15 cycles per second to a 1P21 photomultiplier. The 30-cycle voltage developed by the polarized component of the light is selectively amplified and mixed with a phasing voltage in such a way that the d-c output can be impressed as a sine wave on a Brown recorder. The amplitude of this wave is proportional to the intensity of the polarized light, and the phase of maximum defines the plane of polarization. Records of two

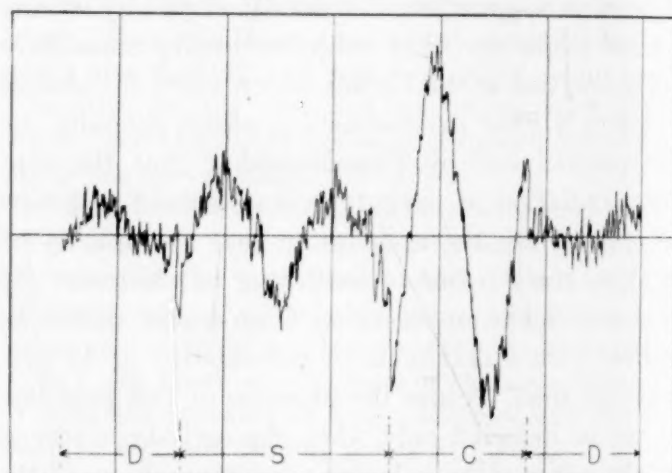


FIG. 2. Star HD 24760, ϵ Persei. This bright star is not generally considered to be a reddened B-type star. Polarization, 0.5%; position angle, -68° .

scatter, however, is much greater than the accidental errors of the observations.

The dependence of polarization on color was determined on three nights from observations of ζ Persei using Schott filters UG1 and BG14 for the ultraviolet region and RG1 or a Wratten yellow filter for the red region. The effective wavelengths of the two spectral regions were near 3,700 Å and 6,200 Å. The observed percentages with the ultraviolet filter were 2.0, 1.6, and 1.8; and with the red filter, 1.6, 1.0, and 2.2. The average value obtained when no filter was used is 1.8 percent. A second star, HD 33,203, was observed on one night, the result being 1.8 in the ultraviolet, 2.2 in the red, and 1.8 with no filter. No definite variation of the orientation of the plane of polarization with color is indicated by these observations.

Fig. 4 shows the observed planes of polarization for 28 early-type stars. The amount of polarization and the orientation of the plane of each is indicated by the length and direction of the line, whose midpoint represents the position of a star. The group of seven stars near the middle of the diagram exhibit a remarkable

a new type of photometer, we obtained some evidence of polarization in the light from one star, CQ Cephei. Accordingly it was planned to make a second trial at McDonald during the summer of 1948 with improved equipment, but a second trial could not be made because of other obligations incurred by my transfer

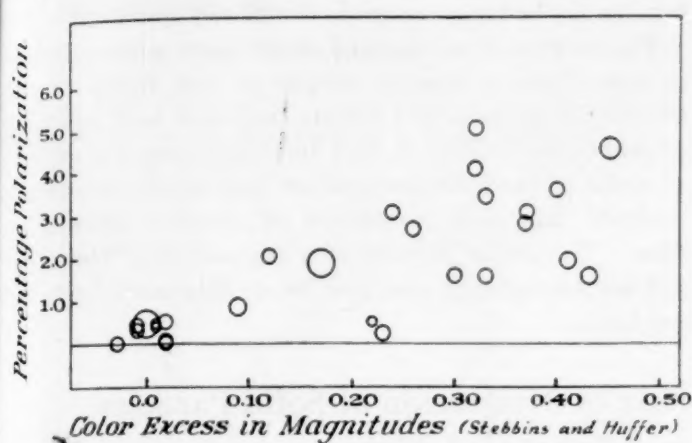


FIG. 3. Observational evidence of a correlation between color excess and percentage of polarization for early-type stars. The size of the circle indicates the weight of the observations.

similarity in percentages of polarization and orientations of the planes, which may be a consequence of the relative homogeneity of the obscuring material in the direction from which their light comes.

I have obtained these preliminary results from a project initiated in collaboration with W. A. Hiltner. My grateful appreciation is expressed to Dr. Hiltner and to the Yerkes and McDonald Observatories for the use of the 82-inch reflector for a period of two weeks during the summer of 1947. Despite very unfavorable weather conditions and some difficulty with

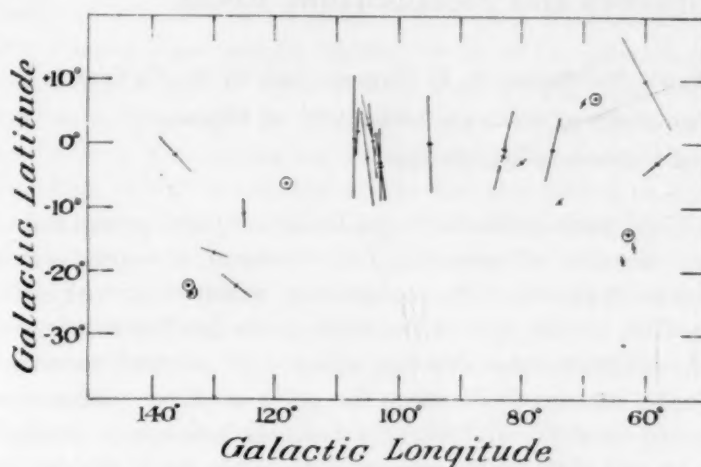
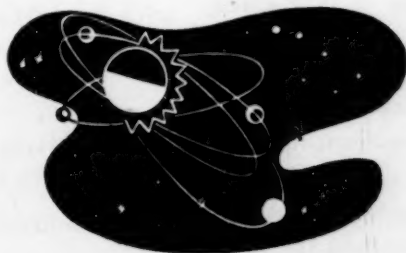


FIG. 4. Observational evidence that there is no one preferential orientation of the plane of polarization. Stars showing no polarization are represented by circles.

from Amherst to Washington on September 1, 1948. With the improved photometer, however, it was easily possible to detect polarization in the light from CQ Cephei with the 18-inch refractor at the Amherst College Observatory. Furthermore, these observations, made during the summer of 1948, showed little if any change in the amount of polarization with the phase of this eclipsing binary star. Meanwhile, Dr. Hiltner's independent work presumably had progressed so far that he did not feel justified in accepting my proposal, made in November 1948, to prepare a joint paper on our work.

References

1. HALL, JOHN S. *Astronom. J.*, 1948, **54**, 39.
2. HILTNER, W. A. *Science*, 1949, **109**, 165.
3. STEBBINS, J., and HUFFER, C. M. *Publ. Washburn Observ.*, 1934, **15**, 5.



TECHNICAL PAPERS

Structural Control in the Formation of Gneisses and Metamorphic Rocks¹

W. H. Newhouse, A. F. Hagner, and G. W. DeVore
University of Chicago, University of Illinois,
and University of Chicago

Field work in the Laramie Range, Wyoming, has led to the concept of migration of chemical elements along planar features such as layering, schistosity, and sub-parallel, closely spaced fractures in the host rock. Gneissic structure may develop along and parallel to these planar features. Plotting the poles of these planes (as shown by strike and dip) on Schmidt hemisphere projections and plotting the composition of the rocks which the poles represent make possible an exact comparison of lithologic composition and structural attitude. A large number of such projections have been made of Pre-Cambrian rocks in Wyoming and Colorado. The results indicate a surprisingly close control of composition of the "guest" by structure of the host. Stress with uniform orientation over regions of hundreds of square miles during each "intrusive" period acted to "open" a set or conjugate sets of planes in the host rock. These relief planes in the guest, when projected and contoured in the structural diagrams, give the center or centers of the most open planar features. The centers of the most open structures for each of the succession of intrusions progress linearly across the diagram, indicating progressive shifts in the orientation of regional stress between intrusive periods. The schist facies display similar variations, indicating a close relation between structural attitude and facies of guest. The most open centers (pole concentrations) for the several schist facies march across the diagram roughly parallel to the line followed by the centers of the time succession of intrusions.

Detailed quantitative work on three gneisses in Wyoming gives a striking mineral variation within each one related to an angular variation of as little as 10° to 20°. The line from basic to more acidic gneiss within each rock unit is roughly parallel to the "time" line of intrusions and the facies line of the schists.

It is in accord with stress-strain theory to suppose that during each spasm of stress, planes of certain attitude would have least normal pressure and thus form "openings," whereas others, differently oriented, would have most normal pressure and thus be the most "closed" planes of the region. The latter should include the host rocks that have suffered least migration of elements. This would be the "closed chemical system" portion of an area, in contrast to the "open chemical system" in the

open structure. Data available are adequate for a partly quantitative comparison of structure and composition, but the method may be made completely quantitative.

The viewpoint and method should have wide application in either field or mineral studies of rock facies. In addition to the gneisses and schists that have been mentioned, amphibolites, dolomites, and iron-formation are examples of rocks of variable composition that might be profitably studied. Regional correlation of gneissic rocks is possible. The strain pattern of a region being "intruded" and metamorphosed can now be studied with fairly high precision.

Rate of Nucleation of Solid Particles in a Subcooled Liquid

J. C. Fisher, J. H. Hollomon, and D. Turnbull
General Electric Research Laboratory,
Schenectady, New York

There are many instances, particularly in the nucleation of solid particles from a subcooled liquid, in which transformation appears to take place only after a critical amount of supercooling. For example, in the formation of ice from a cloud of water drops, Cwilong (1) and Schaefer (2) observe snow to form at a critical temperature of about -38° C. Above this temperature, under most conditions, practically no ice is observed, although the cloud cannot be subcooled below this temperature without rapid transformation of the water to ice. It is the purpose of this paper to show that the existence of such a critical temperature is consistent with the theory of nucleation.

According to nucleation theory (2, 4, 5), the rate of nucleation of solid crystals in a mol of liquid is

$$\dot{n} = (NkT/h) \exp(-\Delta F^*/kT), \quad (1)$$

where

$$\Delta F^* = (16\pi/3) \sigma^3 / \Delta F_v^2 \quad (2)$$

is the local free-energy change on forming a nucleus of critical size, σ is the solid-liquid interfacial tension, and ΔF_v is the free-energy change per unit volume associated with the transformation.

Approximating ΔF_v as

$$\Delta F_v \approx \Delta H_v (1 - T/T_0), \quad (3)$$

where ΔH_v is the latent heat of fusion per unit volume and T_0 is the equilibrium temperature, the value of $\ln \dot{n}$ is

$$\ln \dot{n} = \ln (NkT/h) - 16\pi \sigma^3 T_0^2 / 3kT \Delta H_v^2 (T_0 - T)^2. \quad (4)$$

The lowest temperature, T_c , to which the liquid can be subcooled is evidently that for which $\ln \dot{n} \approx 0$, giving the relationship

$$\ln (NkT_c/h) = 16\pi \sigma^3 T_0^2 / 3kT_c \Delta H_v^2 (T_0 - T_c)^2. \quad (5)$$

When the interfacial tension, σ , is known, the above equation can be solved for T_c , the minimum temperature to

¹ Published with the permission of the Director, Geological Survey, U. S. Department of the Interior, and the State Geologist, Geological Survey, Wyoming.

which the liquid can be subcooled. Alternatively, when the value of T_c is known, the equation can be solved for the interfacial tension, σ .

Consider, for example, the freezing of water, for which the value of T_c is known to be $T_c = -38^\circ \text{C}$. Taking $T_0 = 273^\circ \text{K}$, $T_c = 235^\circ \text{K}$, $\Delta H_v = 80 \text{ cal/cc} = 3.34 (10)^9 \text{ ergs/cc}$, the value of the ice-water interfacial tension, σ , determined from equation (5) is

$$\sigma = 32.8 \text{ ergs/cm}^2. \quad (6)$$

By using this value of σ in equation (1), the rate of nucleation, \dot{n} , can be obtained as a function of T :

$T^\circ \text{C}$	$\log_{10} \dot{n}$
0	$-\infty$
-33	-10.89
-34	-8.33
-35	-5.98
-36	-3.82
-37	-1.84
-38	0
-39	+1.70
-40	3.27
-41	4.74
-42	6.10
-43	7.37

It is of interest to note that the rate of nucleation changes by a factor exceeding 10^{18} in a 10° temperature range including T_c as midpoint. T_c , therefore, resembles a critical temperature, in that water cooled to a few degrees above T_c can persist as liquid for many years on account of the small rate of nucleation of ice. However, on lowering the temperature from a few degrees above T_c , the rate of nucleation increases so rapidly that subcooling below T_c is highly improbable.

References

1. CWILONG, B. M. *Nature, Lond.*, 1945, **155**, 361.
2. FISHER, J. C., HOLLOMON, J. H., and TURNBULL, D. *J. appl. Phys.*, 1948, **19**, 775.
3. SCHAEFER, V. J. *Science*, 1946, **104**, 457.
4. TURNBULL, D., and FISHER, J. C. *J. chem. Phys.*, 1949, **17**, 71.
5. VOLMER, M. *Kinetik der Phasenbildung*. Dresden-Leipzig: Steinkopff, 1939.

The Reduction of 2,3,5-Triphenyltetrazolium Chloride by *Penicillium chrysogenum*¹

Rosalie Broun Fred and S. G. Knight

Department of Agricultural Bacteriology,
University of Wisconsin

The use of the tetrazolium salts, especially 2,3,5-triphenyltetrazolium chloride, to indicate cell viability is apparently well established. Triphenyltetrazolium chloride (TTC) has been used to indicate the germinability of seeds (3), and as a histological agent and a reagent in rapid penicillin assays with *Staphylococcus aureus* (4).

¹This work was supported in part by a grant from the Bristol Laboratories, Inc., Syracuse, New York, and is published with the approval of the director of the Wisconsin Agricultural Experiment Station.

Its use as a reagent in physiology depends upon the enzymic reduction of the soluble colorless triphenyltetrazolium salt to an insoluble carmine red formazan. At this laboratory TTC has been used in studies on the physiology of the penicillin-producing strains of *Penicillium chrysogenum*.

Penicillium chrysogenum Q176 was grown in shaken flasks of 2% corn steep solids-2% lactose medium after the manner described by Koffler, *et al.* (2). After harvesting, the pellets were washed free of pigments and nutrients, suspended in M/15 phosphate buffer, and torn apart by a 5-sec treatment in a Waring Blendor. After blending, a buffer solution of the dye was added to give a final concentration of 0.5% TTC. The buffer used throughout was at pH 7.2-7.4, because the reduction of the dye was retarded at a lower pH and was virtually stopped at pH 6.

Under these conditions the most active mold cells would reduce the dye to a deep red color in 20 min at 30°C . Table 1 shows the relative ability of *Penicillium chrysogenum* Q176 of different ages to reduce the dye to a colored formazan and gives the penicillin yields at the time of harvest.

TABLE 1

A CORRELATION BETWEEN THE RATE OF TTC REDUCTION AND PENICILLIN YIELDS BY MYCELIUM OF *Penicillium chrysogenum* Q176 AT DIFFERENT AGES

Age of mycelium (Days)	Color	Penicillin yield (Oxford units/ml)
1	deep red	0
2	deep red	0
3	red	0
4	pink-red	0
5	pink-red	42
6	yellow-pink	294
7	yellow-pink	440
8	yellow (color of mycelium)	310

These experiments have been repeated on other penicillin-producing molds with the same results. Thus, if TTC reduction is an indicator of cell viability, it is evident that young nonpenicillin-producing cells (1-3 days old) are much more viable than the older penicillin-producing cells (5-7 days old). In other words, penicillin is formed by the mold when its metabolic state is considerably reduced. That penicillin is formed by the mold when its metabolic state is low or abnormal has been suggested (1). These findings with TTC have been checked with the vital stains Nile blue sulfate and neutral red. The cytoplasm of young cells that readily reduced TTC stained deeply and homogeneously, while cells 5 to 7 days old stained unevenly and showed the granules and vacuoles typical of aged cells.

TTC was reduced only inside the cells and the addition of glucose did not change the rate or site of reduction; apparently the endogenous activity of the mycelium was more than sufficient to reduce the dye. The inhibitor KCN inhibited reduction at M/100 final concentration

and slowed reduction at M/1,000. Sodium malonate, sodium azide, 2,4-dinitrophenol, sodium fluoride, and iodoacetic acid merely slowed reduction at M/100 final concentration. Undecylenic acid, a fungicidal agent, stopped reduction completely. From this lack of specificity for inhibitors it would seem that a number of reducing enzymes acting on materials inside the cell can reduce the dye. Aeration by shaking retarded reduction, perhaps because it raised the redox potential too high (over -0.08 v) or because oxygen competed with the TTC.

Experiments on the reduction of TTC by *Penicillium chrysogenum* have added proof to the theory that penicillium is formed by a relatively inactive mold. Apparently a number of reductases can reduce the dye to the colored formazan. TTC promises to be an interesting and useful reagent in studies on cellular physiology.

References

1. KNIGHT, S. G. *J. Bact.*, 1948, **55**, 401.
2. KOFFLER, H., EMERSON, R. L., PERLMAN, D., and BURRIS, R. H. *J. Bact.*, 1945, **50**, 517.
3. PORTER, R. H., DURRELL, M., and ROMM, H. J. *Plant Physiol.*, 1947, **22**, 149.
4. PRATT, R., and DUFRENOY, J. *Stain Tech.*, 1948, **23**, 137.

Existence of a Tryptophan-Niacin Relationship in Corn

Alvin Naso¹

Department of Botany, Columbia University

The role of tryptophan as a precursor of niacin (nicotinic acid) and its metabolites, especially in the presence of adequate amounts of vitamin B₆, has been demonstrated by recent investigations with mammals (3, 5-7). It has also been shown that tryptophan serves as a niacin precursor in the fungus *Neurospora* by way of kynurenine and 3-hydroxy anthranilic acid (2, 4). On the other hand, neither tryptophan nor any of its intermediates indicated in *Neurospora* seems to affect niacin production in *Lactobacillus arabinosus* and certain other microorganisms (10). It has also been reported that the tryptophan-niacin relationship does not exist in the case of bean seedlings grown without their cotyledons on synthetic media (9). The present study, however, indicates that a tryptophan-niacin relationship, like that found for certain mammals and *Neurospora*, may exist in a representative higher plant. Experiments in this laboratory have demonstrated that the addition of L-tryptophan to the nutrient medium results in a significantly increased niacin content in mature excised corn embryos grown in sterile culture.

Seeds of a genetically high-niacin corn (Tennessee Inbred 13)² were sterilized with HgCl₂ and soaked in water overnight. The embryos (including scutella) were removed intact by sterile excision and transferred to individual Erlenmeyer flasks containing a liquid medium consisting of mineral salts, sucrose, and certain vitamins. Two sets of experiments were conducted.

¹ Lalor Fellow.

² This seed was kindly supplied by Mr. F. D. Richey of the U. S. Department of Agriculture.

In experiment I various combination concentrations of L-tryptophan and vitamin B₆ (equimolar quantities of pyridoxine, pyridoxamine, and pyridoxal) were added to each 10 ml (per flask) of the basal nutrient solution. The L-tryptophan and B₆ were previously sterilized by bacteriological filtration. The embryos were grown in the dark at 25° C for 10 days and assayed for niacin by

TABLE 1

NIACIN CONTENT OF EXCISED CORN EMBRYOS GROWN FOR 10 DAYS IN DARK WITH VARIOUS CONCENTRATION COMBINATIONS OF L-TRYPTOPHAN AND VITAMIN B₆

Experiment I

Treatment (per embryo)	Number of embryos	Average μ g niacin per seedling	μ g Niacin per gm dry wt
Control	7	5.07	55.8
100 μ g L-tryptophan + 100 μ g vitamin B ₆	8	6.24	62.7
100 μ g L-tryptophan + 50 μ g vitamin B ₆	6	5.78	60.9
100 μ g L-tryptophan + 10 μ g vitamin B ₆	6	6.32	62.3
Mean		6.11 \pm 0.17*	62.0 \pm 0.6*
500 μ g L-tryptophan + 100 μ g vitamin B ₆	8	7.44	73.7
500 μ g L-tryptophan + 50 μ g vitamin B ₆	4	6.36	73.1
500 μ g L-tryptophan + 10 μ g vitamin B ₆	9	6.54	70.4
Mean		6.78 \pm 0.33*	72.4 \pm 1.0*
1000 μ g L-tryptophan + 100 μ g vitamin B ₆	8	8.71	85.7
1000 μ g L-tryptophan + 50 μ g vitamin B ₆	8	8.55	96.3
1000 μ g L-tryptophan + 10 μ g vitamin B ₆	9	7.79	86.0
Mean		8.35 \pm 0.29*	89.3 \pm 3.5*

* Standard error.

the microbiological method employing *Lactobacillus arabinosus* (1). Experiment I reveals (Table 1) niacin synthesis in excess of that of the controls to be a direct function of L-tryptophan supply and to be independent of the concentration of vitamin B₆ employed. On a per-plant basis niacin was increased as much as 64% over the controls when 1,000 μ g of L-tryptophan, with various concentrations of B₆, were added to the nutrient solution.

In experiment II the effects on niacin synthesis of L-tryptophan and vitamin B₆ individually, as well as in combination, were studied. The data (Table 2) show that the addition of 1,000 μ g of L-tryptophan, singly or in combination with vitamin B₆, resulted in a 35% to 42% increase in niacin synthesis over that of the controls on both a per-plant and a dry weight percentage basis. Statistical examination of these data by use of the *t* test and by analysis of variance (multiple classification) (8) show the increase to be highly significant ($P < 1\%$). However, the use of L-tryptophan and vitamin B₆ in combination resulted in only a 7% to 9% increase in niacin production

above that obtained by using L-tryptophan alone. This increment is not statistically significant. Nor did the addition of vitamin B₆ alone significantly increase niacin synthesis over that of the controls as checked by the same statistical procedure. The increment was only 3% to 5%. The quantitative differences in the responses of

TABLE 2

NIACIN CONTENT* OF EXCISED CORN EMBRYOS GROWN FOR 10 DAYS IN DARK WITH AND WITHOUT L-TRYPTOPHAN AND VITAMIN B₆

Experiment II

Treatment (per embryo)	Number of embryos	Average μ g niacin per seedling	Average μ g niacin per gm dry wt
Control	45	$5.22 \pm 0.11^\dagger$	$63.4 \pm 0.1^\dagger$
53 μ g vitamin B ₆	45	5.38 ± 0.16	66.3 ± 1.0
1000 μ g L-tryptophan	35	6.60 ± 0.28	85.6 ± 1.5
53 μ g vitamin B ₆ plus 1000 μ g L-tryptophan	40	7.06 ± 0.01	90.1 ± 1.4

* Each niacin value represents the mean of 5 replicated treatments, each treatment involving 7-9 seedlings.

† Standard error.

embryos in the two experiments were probably due to the use of seeds from two different crops of the same genetic line.

Niacin assays of the nutrient solutions in which the embryos had been grown indicate that a negligible amount of niacin ($< 0.1 \mu$ g per plant) was lost by the embryos to the nutrient medium.

It would appear from these experiments with excised embryos that a tryptophan-niacin relationship exists in corn, and that it is independent of added vitamin B₆. Clarification of the role of tryptophan in this relationship, as well as in the normal metabolism of intact corn plants, will be a subject for future investigation. Such information will have added importance in view of the characteristically low tryptophan content of corn.³

References

1. ASSOCIATION OF VITAMIN CHEMISTS. *Methods of vitamin assay*. New York: Interscience, 1947.
2. BEADLE, G. W., MITCHELL, H. K., and NYC, J. F. *Proc. nat. Acad. Sci.*, 1947, **33**, 155.
3. LING, C. T., HEGSTED, D. M., and STARE, F. J. *J. biol. Chem.*, 1948, **174**, 803.
4. MITCHELL, H. K., and NYC, J. F. *Proc. nat. Acad. Sci.*, 1948, **34**, 1.
5. ROSEN, F., HUFF, J. W., and PERLZWEIG, W. A. *J. biol. Chem.*, 1946, **163**, 343.
6. SCHWEIGERT, B. S., and PEARSON, P. B. *J. biol. Chem.*, 1947, **168**, 55.
7. SCHWEIGERT, B. S., PEARSON, P. B., and WILKENING, M. C. *Arch. Biochem.*, 1947, **12**, 139.
8. SNEDECOR, G. W. *Statistical methods*. Ames, Iowa: Collegiate Press, 1946.
9. TERROINE, T. *Compt. Rend.*, 1948, **226**, 511.
10. VOLCANI, B. E., and SNELL, E. E. *Proc. Soc. exp. Biol. Med.*, 1948, **67**, 511.

³ Appreciation is expressed to Prof. R. F. Dawson of Columbia University for his interest and helpful suggestions.

A New Method of Freezing Eggs in the Shell and Its Possibilities for Further Application on Freezing Foods in General

Socrates A. Kaloyereas

Department of Agricultural Chemistry and Biochemistry, Louisiana State University, Baton Rouge

Present methods of preserving eggs by freezing require that the eggs be broken out of their shells, stirred to break the membranes, and stabilized by the addition of some material such as salt or sugar (9). The use of this product is limited to bakeries, confectioneries, and similar commercial establishments.

Up to the present time, eggs in the shell have been preserved only at temperatures above the freezing point of water. Ordinary cold storage, a combination of cold storage and gas storage (7), and other more or less empirical procedures (8) are commonly used. All these methods possess certain disadvantages including displacement of the yolk, weakening of the vitelline membrane, considerable loss of weight, acquisition of off-odors and flavors during storage, and various other minor changes.

A method has been developed in this laboratory for freezing eggs without cracking the shell. This minimizes the above undesirable changes, and the eggs are suitable for home use. Furthermore, the resistance of the embryo to freezing temperatures is increased, as shown by hatchability tests now in progress.

The beginning of the process goes back to 1937, when the author was working on the freezing of mushrooms at the Low Temperature Institute, Cambridge, England. There the idea came to him that if the amount of water corresponding to the expansion of the ice formed by freezing were removed uniformly from the tissues, it would probably prevent the disruption of the cells and obviate blanching. The preliminary tests at Cambridge indicated that this idea, despite the fact that the amount of water to be removed from the mushroom was found to be much more than the amount anticipated, was not without merit. The work was continued with more or less successful results on various other products in the laboratory at the Food Research Experiment Station, Athens, Greece, where the author was in charge until 1945. Meanwhile, in 1939, he obtained a Greek patent (4) on a process of freezing foods following partial dehydration which actually is the first original and theoretically established process of dehydrofreezing. The work was interrupted by the war, but resumed in Louisiana in 1946.

Since it appeared that expansion of the ice formed from the water of the tissues was the primary cause of most of the major changes occurring during freezing, a study was undertaken of the mechanism of these changes by associating them with the drip (the liquid exuded from the product during thawing). Adequate methods of measuring the drip have been developed (5, 6), and and by their use it has been possible to accumulate a multitude of data, to be published later, corroborating

the validity of the assumption that expansion is the primary factor involved in the changes which occur during freezing. One of the controlling factors in the process

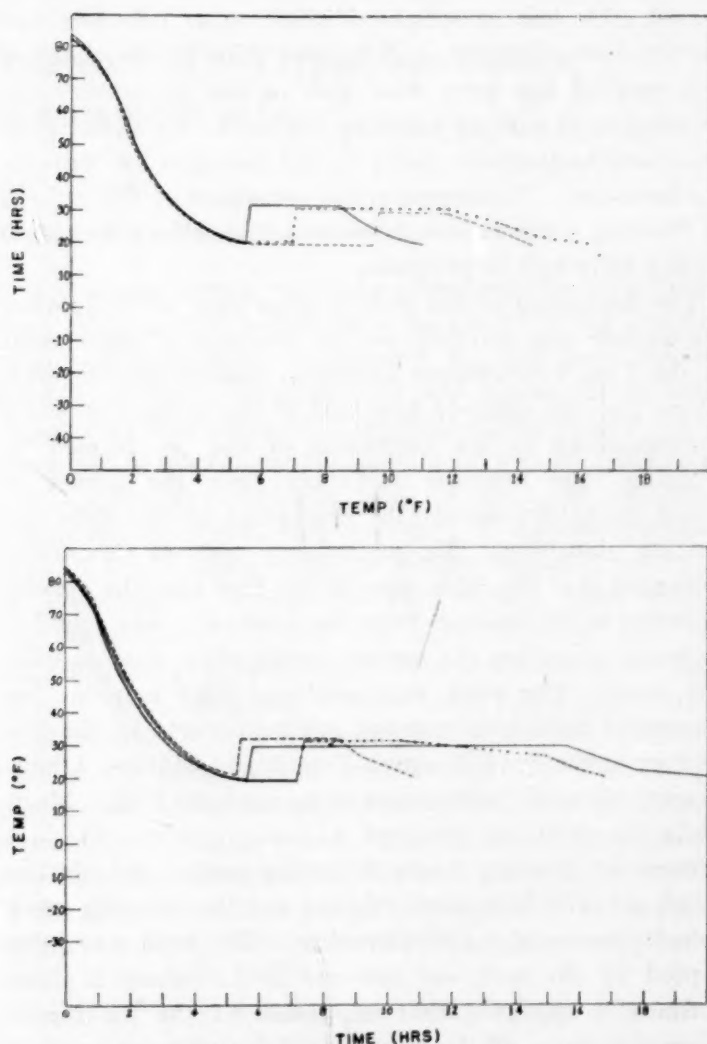
and its water-ice curve (3) was estimated to be 6.1%. The actual experiment showed, however, that elimination of a smaller amount (2-3%) was sufficient for freezing

TABLE 1
AVERAGE VALUES OF CONSTANT PROPERTIES OF EGG WHITES AND YOLK BEFORE AND AFTER TREATMENT (to a Loss of 8% Wt)

	Before treatment			After treatment		
	Liquid	Solid	Yolk	Liquid	Solid	Yolk
Percentage of liquid and solid whites	41	59	49	51
Refractometer reading	14.63	14.61	48.38	17.17	16.76	48.53
pH	8.32	8.24	6.09	8.89	8.99	6.07
Redox potential millivolts at pH 7.0	+158	+156	+116	+139	+133	+95
Freezing point	-0.47	-0.52	-0.58	-0.78	-0.58	-0.60
Expansion by freezing at 20° F	7.20	7.50	2.5	4.85	5.20	2.40
Bound water	3.22	3.39	5.83	3.45	3.66	6.095

of expansion during freezing is the relationship of bound water to free water, which determines also the amount of drip. Dehydration affects this relationship as well as drip, though to a lesser extent in the freezing of eggs than in the case of other products.

eggs under vacuum without cracking. After finding that the treatment does not greatly change the bound water (the amount of which is rather small) of the egg whites and yolk (Table 1), the effect of a vacuum upon the properties of the egg whites and yolk was examined, since



FIGS. 1-2. Rates of freezing of the yolk (-----), thick whites (———), and (.....) thin whites of untreated (top) and treated (bottom) eggs.

In the case of eggs the problem was to reduce the water content to the extent needed to provide space for the expansion of the ice formed by freezing. The necessary decrease in weight based on the water content of the egg

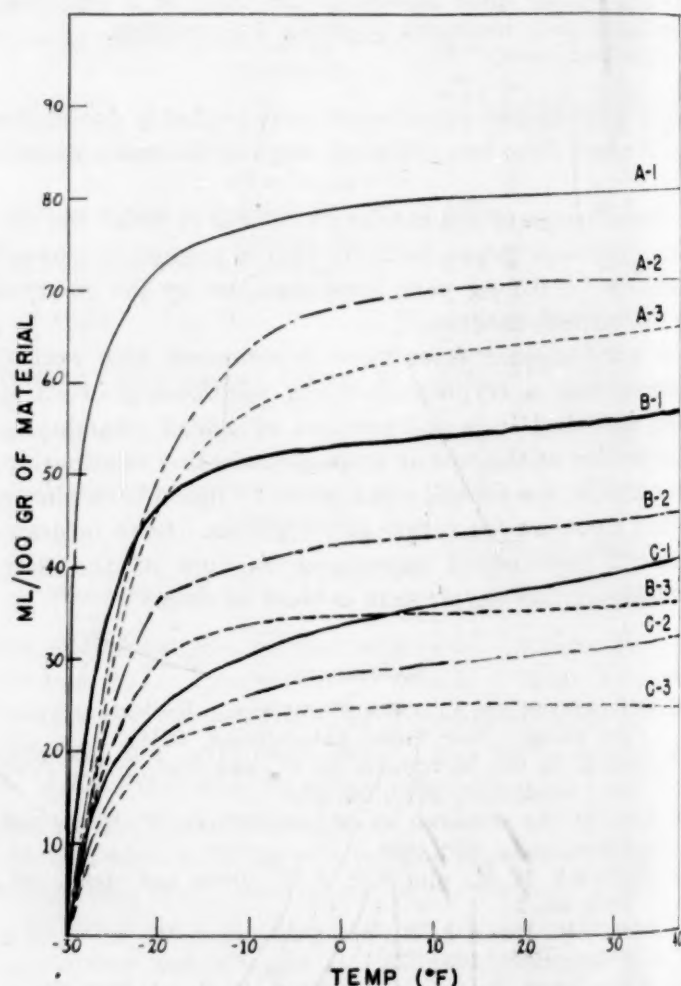


FIG. 3. Expansion of the white and yolk of the egg. A—white: 1, untreated; 2, treated; 3, treated and frozen under vacuum. B—whole eggs: 1, untreated; 2, treated; 3, treated and frozen under vacuum. C—yolks: 1, untreated; 2, treated; 3, treated and frozen under vacuum.

vacuum has been used together with dehydrating agents for the prefreezing treatment. Determinations of the expansion of the egg whites and yolk before and after treatment under vacuum, as well as of their rate of

freezing under vacuum, proved tedious until we were able to devise methods which gave reproducible results. The details of these methods will be published later.

The results appearing in Table 1 and graphically in Figs. 1-3 show that freezing treated eggs under vacuum decreases considerably their expansion during freezing and reverses the rate of freezing in the various parts of the egg content when freezing takes place at about 20° F. In the fresh, untreated eggs the white freezes first and creates a solid wall around the yolk, so that when the latter freezes there is no room for expansion and the egg cracks. When the eggs are treated and frozen under vacuum, the yolk freezes first and pushes the white toward the shell so that all the room available in the air space is used during the expansion of the white. This, of course, allows better utilization of the space available within the egg. Removal of the gas from the yolk, on the one hand, and lowering of the freezing point of the white by the treatment, on the other, seem the probable explanation of this surprising result. A contributing factor also is the small decrease in volume of the thick white during the freezing of the treated eggs through a partial breaking down of its mucin content, due probably to the change of pH under the reduced pressure of CO₂ (1), a fact which is associated with a change in volume. In one particular case, where the change of thick white to liquid was about 50%, the change in volume was about 3%. All these factors working together help to secure a better economy of space within the egg during freezing and reduce the necessary treatment to a minimum. Under these conditions the treatment does not affect the quality of the eggs at all; on the contrary, the whipping quality of the white is somewhat improved. The loss of weight during storage at 20° F and 85% relative humidity was, in our experiments, 0.15% per month, in comparison with a 0.23% loss obtained during the storage at about 32° F. This loss would be still less if the humidity of the room were kept higher. Eggs kept in an under-cooled condition at 23° F for 7 months lost 1.8-2.9% (10), and if the theoretical formula developed by Greenlee (2) is valid, the calculated loss at storage temperatures below 28° F is zero.

References

1. BROOKS, T., and PACE, T. "The Equilibria Between Carbon Dioxide and the Egg," Food Invest. Board, 1938, 37-38.
2. GREENLEE, A. D. *Amer. chem. Soc.*, 1912, **25**, 539.
3. HEISS, R. "Recherches au sujet des besoins de froid et de pourcentage d'eau congelée au cours de la congélation rapide et de la congélation lente des denrées alimentaires," Institut International du Froid Paris Anex 193, 25-38.
4. KALOYEREAS, SOCRATES A. "A New Method for Freezing Foods," Patent No. 8026-25 February 1939, Athens, Greece.
5. KALOYEREAS, SOCRATES A. *Food Res.*, 1947, **12**, 419.
6. KALOYEREAS, SOCRATES A. *Fruit Prod. J.*, 1947, **27**, 6.
7. MORAN, T. *Z. Ges. Kälte Ind.*, February 1938, Heft 2.
8. ROLET, A. *Les Conserves*, 1920, **2**, 169-219.
9. TRESSLER and EVERS. *Freezing preservation of foods*, 1947. P. 636.
10. TUCHSNEID, M. W. *Die kältetechnologische Verarbeitung schnellverderblicher Lebensmittel*, 1936. P. 357.

Reversal to Penicillin Sensitivity in a Cysteine-requiring Mutant of *Salmonella*¹

H. H. Plough and Madelon R. Gramm

Biological Laboratory, Amherst College

The action of penicillin in producing bacteriostatic and bactericidal effects is believed to be due to chemical interactions with essential SH and perhaps NH₂ groups in the medium (Bailey and Cavalitto, 1), and so a metabolic block is produced which may be irreversible. Additional evidence for the point of view that penicillin is a metabolic antagonist has recently been given by Wilson and du Vigneaud (7), who showed that L-penicillamine—but not D-penicillamine—inhibits the growth of young rats when added to a diet which otherwise permits good growth. When aminoethanol and methylated derivatives were added to the L-penicillamine-containing diet the inhibiting effect of the latter was counteracted. More direct evidence of specific metabolic antagonism is given by Gale and Rodwell (2), whose experiments with *Staphylococcus* are interpreted as showing that penicillin acts to impair the ability to assimilate glutamic acid. These investigators have studied the nutritional requirements of penicillin-sensitive *Staphylococcus*, and of resistant strains derived from the original culture by training or mutation. It appears that the parental strains cannot synthesize most of the essential nutrilites, but can concentrate within the cell free amino acids, especially glutamic acid, provided they are available in the surrounding medium. The mutant resistant strains have lost the ability to concentrate free glutamic or other amino acids, but have concurrently developed the power to synthesize all these essential nutrilites within the cell from their inorganic constituents. Since the mutant strains are thus not dependent for growth on the assimilatory processes they should be independent of the antagonistic effects of penicillin, as they are.

These studies still leave many questions unanswered. One of the most obvious concerns the status of the Gram-positive organisms like *Bacillus subtilis*, which are heterotrophic, i.e., synthesize all their nutrilites except glucose, yet are still penicillin-sensitive. It is of considerable interest, therefore, to test the penicillin sensitivity of nutritional mutants of other bacteria, particularly those that are originally penicillin-resistant.

We wish to record one such series of tests in a Gram-negative organism, the results of which give excellent correlation with the metabolic antagonism theory of the action of penicillin. We are studying radiation-induced mutations in *Salmonella typhimurium*, a food poisoning pathogen which is heterotrophic and highly resistant to penicillin. A number of different kinds of mutations

¹ Supported in part by a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council.

have been studied (Plough, 5), some of which were isolated by the methods of Tatum (6) and show the loss of certain enzyme systems normally carrying on specific essential syntheses, and so require one or more nutrilites in the medium. One of these mutant strains (#10-1)

TABLE 1

Medium	International units of penicillin						
	4	2	1	0.5	0.25	0.125	0.062
<i>Original S. typhimurium</i> #511							
Infusion broth	+++	+++	+++	+++	+++	+++	+++
S.D. + Casamino acid	+	+	++	++	++	++	++
S.D. + cysteine	-	+	+	+	+	+	+
S.D. + tryptophane	-	+	+	+	+	++	++
S.D. alone	-	+	+	+	+	+	+
<i>Mutant strain</i> #10-1							
Infusion broth	-	-	++	+++	+++	+++	+++
S.D. + Casamino acid	-	-	+	+	++	++	++
S.D. + cysteine	-	-	-	-	+	+	+
S.D. - tryptophane	-	-	-	-	-	-	-
S.D. alone	-	+	+	+	+	+	+

isolated after ultraviolet radiation, requires the amino acid cysteine, which the parental strain can synthesize. Thus we have here exactly the opposite situation from that studied in *Staphylococcus* by Gale and Rodwell. The original *Staphylococcus* is Gram-positive, requires amino acids in the medium, and is penicillin-sensitive. The mutant strains can synthesize their own amino acids and are penicillin-resistant. Our original *Salmonella* is Gram-negative, can synthesize amino acids, and is penicillin-resistant. Our mutant cysteine-requiring *Salmonella* turns out to be much more penicillin-sensitive.

The tests were made by the tube method of assay (Plough, 4), using a graded series of dilutions of penicillin in complete broth medium, and in synthetic medium containing dextrose and essential salts² plus particular nutrilites. Growth readings of visible turbidity were made at 24 hours. Results are shown in Table 1.

It is clear that the mutant strain #10-1 is more sensitive to penicillin than the parent strain, both when complete infusion broth medium is used and when the test is made in synthetic medium with complete nutrilites (S.D. + Casamino acid), or synthetic with the essential cysteine (S.D. + cysteine). When synthetic medium and tryptophane or synthetic medium alone is used, the essential cysteine is not present, and so there is no growth, regardless of penicillin.

This result brings *Salmonella* into line with the interpretation of Gale and Rodwell, though the wild type is the opposite of *Staphylococcus*. It further supports the conclusion that penicillin antagonizes the assimilation of

² The composition of the synthetic medium (noted in the table as S.D., salts and dextrose) was as follows, after MacLeod (3): NaCl 5.00 g; (NH₄)₂SO₄ 4.72 g; KH₂PO₄ 2.72 g; dextrose 2.00 g; plus 1 ml of a solution containing 1 g each of FeCl₂, MgCl₂ and CaCl₂ in 600 ml. Distilled H₂O was added to make 1 l and pH was adjusted to 7.00 with N NaOH.

When Casamino acid is noted it was "Vitamin-free Casamino acid" Difco, a product hydrolyzed from casein.

one or more amino acids inside the bacterial cell. Study of the mechanism of the metabolic block and of other reactions of other mutant strains is being continued.

References

1. BAILEY, J. H., and CAVALITTO, C. J. *J. Bact.*, 1948, 55, 175-181.
2. GALE, E. F., and RODWELL, A. W. *J. Bact.*, 1948, 55, 161-167.
3. MACLEOD, C. M. *J. exp. Med.*, 1940, 72, 217-232.
4. PLOUGH, H. H. *Amer. J. clin. Path.*, 1945, 15, 446-451.
5. PLOUGH, H. H. Radiation induced mutations in chemical requirements in *Salmonella typhimurium*, 1948. (Oak Ridge National Lab., in press.)
6. TATUM, E. L. *Cold Spr. Harb. Symp. quant. Biol.*, 1946, XI, 278-284.
7. WILSON, J. E., and DU VIGNEAUD, V. *Science*, 1948, 107, 653.

Inhibition of Salt Accumulation in Excised Wheat Roots by 2,4-Dichlorophenoxyacetic Acid

James F. Nance

Department of Botany, University of Illinois, Urbana

Widespread interest in the growth effects of 2,4-dichlorophenoxyacetic acid (2,4-D) has led to a number of investigations designed to reveal its mechanism of action. Perhaps the most obvious metabolic effect observed is the striking decrease in the reserve carbohydrates of the treated tissues (5). More recently, changes in the respiratory activity of treated tissues have been reported. Brown (1) found significantly increased CO₂ evolution by bean seedlings 1 to 4 days after application of 2,4-D spray. Hsueh and Lou (2) report a stimulation of germination of rice and barley seedlings at concentrations of about 100 ppm of 2,4-D and, at higher concentrations (up to 1,000 ppm), inhibition of both germination and respiration. Increased CO₂ evolution by the roots of dandelion plants 5 to 15 days after the plants had been sprayed with 2,4-D mixture was observed by Rasmussen (7). Taylor (10) made detailed studies of O₂ uptake and CO₂ evolution of wheat and mustard seedlings (18 to 30 hrs old) treated with 2,4-D solutions of from 0.25 to 10 ppm. Manometric measurements over a period of 24 hours principally revealed decreases in both O₂ and CO₂ exchange in the two types of seedlings. Studies of Smith (8) on the stems of 2,4-D-treated bean seedlings show increases in the respiratory activity of treated tissue when calculated on a dry weight basis but decreased activity when calculated on protein-nitrogen basis. Control tissues were found to be significantly more sensitive to iodoacetate than 2,4-D-treated tissues under anaerobic conditions. Worth and McCabe (12) compared the effects of 2,4-D on the growth of several species of aerobic, facultatively anaerobic, and anaerobic bacteria. Growth of the aerobic organisms was greatly inhibited in 3 out of 4 organisms by concentrations of from 0.2% to 2% 2,4-D. Facultative anaerobes were not inhibited at any concentration and were stimulated at concentrations of from 0.002% to 0.2% in all cases. Growth of anaerobic

bacteria was inhibited over a wide range of concentrations of 2,4-D.

Preliminary results of studies concerned with the effect of 2,4-D on salt accumulation, which developed from a study of the effect of this compound on nitrate assimilation, are reported below. Excised roots of 4-day-old wheat seedlings were used as plant material. During the growing period the seedlings were supported on Fiberglas gauze stretched tightly over a 2-liter Pyrex crystallizing dish which contained 0.0001 M CaSO_4 . The cultures were aerated and the vessels were kept in a dark room maintained at $22.0^\circ \pm 0.5^\circ \text{C}$. The plants were grown from White Federation 38 seeds harvested in the Sacramento valley of California in 1945. Plant material in each experimental flask consisted of 45 root segments, each 15 mm long, of which 20 were root tips and 25 were from more mature sections of the root. Because a less sensitive method for the chloride determination was used, it was necessary to employ samples of 35 root tips plus

TABLE 1

Time (hrs)	Treatment*	NO_3^- absorbed (meq $\times 10^{-3}$)	Percentage of control
3	KNO_3	0.50	100
	$\text{KNO}_3 + 2,4\text{-D}$	0.20	40
6	KNO_3	2.30	100
	$\text{KNO}_3 + 2,4\text{-D}$	0.60	26
9	KNO_3	3.35	100
	$\text{KNO}_3 + 2,4\text{-D}$	0.90	27

* KNO_3 , 0.001 M; 2,4-D, 10 ppm.

100 of the mature sections in the experiments on chloride accumulation.

For the experiments, the root samples were placed in 5 ml of solution containing 0.001 M KNO_3 or 0.01 M KCl , with various additions, and aerated by shaking in a constant temperature bath at 25°C for 6 hrs. In the nitrate experiments, the culture solutions were decanted from the roots, and the roots washed 3 times at the end of the experiment. Nitrate analyses were made on the combined culture solutions and washings and separately on the roots. The phenoldisulfonic acid method was used following a modification of Burstrom's procedure described earlier (6). Although only culture solution analyses are reported in this paper, analyses on both roots and cultures were necessary to determine the effect of the treatments on the reduction of the nitrate. In the experiments reported below there was no significant nitrate reduction in any treatment. Chloride analyses were made according to Fajan's method (11) on an aliquot of the culture solution. The 2,4-D used was recrystallized twice from a commercial preparation and melted at 134 to 135°C (uncorrected).

Results of a time study (Table 1) show a marked inhibition of nitrate absorption by 10 ppm of 2,4-D within 3 hrs. This effect is clearly a primary 2,4-D inhibition of the accumulation mechanism and not a second-

dary effect following upon a general metabolic disturbance. In Table 2 it may be seen that concentrations

TABLE 2

EFFECT OF CONCENTRATION ON INHIBITION OF NITRATE ABSORPTION BY 2,4-D

2,4-D (ppm)	NO_3^- absorbed* (meq $\times 10^{-3}$)	Percentage of control
0.0	1.90	100
0.1	1.65	87
1.0	1.10	58
5.0	0.65	33
10.0	0.70	37

* KNO_3 in all cases, 0.001 M.

as low as 0.1 ppm are inhibitory. Maximum inhibition was attained with 5 ppm. An attempt to determine the effect of pH on the toxicity of 2,4-D unexpectedly revealed that KH_2PO_4 at 0.001 M (used as a buffer) enhances the 2,4-D inhibition of nitrate accumulation very markedly (Table 3). In the presence of 0.001 M KH_2PO_4 , 1 ppm of 2,4-D restricted the uptake of nitrate to 4% of the control (pH 4.0) to 14% of the control (pH 6.0). These results should be compared to the effect of the same concentration of 2,4-D alone in 2 other experiments reported in Tables 2 and 4, where uptake of nitrate amounts to 58% and 62% of the controls, respectively. Although the inhibition is greater at the lower pH, the differences in absolute amounts are not large enough to indicate a pH relation conclusively. It will be noted that phosphate did not restrict nitrate uptake in the absence of 2,4-D.

TABLE 3

pH of buffer*	2,4-D (ppm)	NO_3^- absorbed† (meq $\times 10^{-3}$)	Percentage of control
6.0	0.0	2.60	100
4.0	1.0	0.10	4
5.0	1.0	0.30	12
6.0	1.0	0.35	14

* KH_2PO_4 , 0.001 M adjusted to pH; indicated with KOH or H_2SO_4 .

† KNO_3 in all cases, 0.001 M.

Attempts to reverse the effect of 2,4-D were made with certain dyes: methylene blue, quinone, and dichlorobenzene indophenol, as well as iodine, cysteine, sodium sulfide, and a normal cellular substrate, citric acid. The dyes and iodine, all used at 10 ppm, enhanced the inhibitory effect of the 2,4-D to a small degree of questionable significance. Sodium sulfide (pH 6.0) at 1×10^{-3} M killed the roots; at 1×10^{-4} M its effect was not significant. Cysteine at 1×10^{-4} M had no significant influence. Citrate alone was able to reverse the 2,4-D inhibition. Its reversal activity was demonstrated in the presence of 1 ppm of 2,4-D and in a second experiment in which the roots were presoaked for 2 hrs in a solution of 25 ppm of 2,4-D, washed, then placed in KNO_3 with and

without added citrate. The citrate concentration was 0.05 M in both cases and adjusted to pH 5.0 with KOH.

TABLE 4
REVERSAL OF 2,4-D INHIBITION

Treatment*		NO ₃ ⁻ absorbed (meq × 10 ⁻³)	Percentage of control
KNO ₃		2.50	100
KNO ₃ + 2,4-D		1.55	62
KNO ₃ + 2,4-D + K citrate		2.45	96
Pre-soaked in 2,4-D‡	KNO ₃	1.40	64†
	KNO ₃ + K citrate	3.40	154†

* KNO₃, 0.001 M; 2,4-D, 1 ppm; K citrate, 0.05 M, pH 5.0.

† Based on average amount of KNO₃ accumulated by 45 root segments (controls) in 6 hrs, from 6 experiments.

‡ Roots aerated in a solution of 25 ppm of 2,4-D for 2 hrs.

Experiments with KCl, one of which is reported in Table 5, indicate that the 2,4-D inhibition of accumulation is not a specific nitrate effect.

It was felt that the 2,4-D inhibition of salt accumulation might be associated with a lower respiratory activity in the treated roots. Oxygen consumption by 45 root segments at 25° C was measured in a Warburg respirometer. The lower initial values in the third test (Table 6) are probably due to the fact that in this case, after they were cut, the roots stood 3 hrs in redistilled water before they were placed in the vessels. In the first 2 tests the roots were placed in the vessels as soon as they were cut.

TABLE 5
2,4-D INHIBITION OF CHLORIDE ABSORPTION

Treatment	Cl ⁻ absorbed (meq × 10 ⁻²)	Percentage of control
KCl (0.01 M)	1.37	100
KCl (0.01 M) + 2,4-D (10 ppm)	0.70	48

Machlis (4) observed a similar effect with barley seedling roots. It may be seen that the oxygen consumption by roots after 5-7 hrs is significantly greater in KNO₃, KNO₃ plus 2,4-D, and 2,4-D alone than it is in distilled water. Differences in oxygen uptake between the roots in KNO₃, KNO₃ plus 2,4-D, and 2,4-D alone are probably not significant in these experiments though it is possible that more intensive studies might reveal such differences. It appears that the inhibition of salt accumulation by 2,4-D cannot be as conclusively related to diminished oxygen consumption as can its inhibition by various respiratory poisons as described by Machlis (4).

The results of the present investigation suggest that 2,4-D brings about a change in the relative amounts of energy released by the various possible respiratory pathways or components. Salt accumulation, for example, might be affected by the 2,4-D inhibition of a particular respiratory component. Lundegardh (3) has, indeed,

presented evidence for the occurrence of two respiratory systems in plant tissues, a cyanide-insensitive system which he calls the "ground respiration" and a cyanide-sensitive system which he designates the "anion respiration." The latter component he associates with salt accumulation. As a consequence of the postulated inhibition of a particular respiratory pathway by 2,4-D and in order to account for the fact that oxygen consumption is not appreciably affected, it might be suggested further that as one component of the respiration becomes less active a second one may assume greater activity.

Another general mechanism for the inhibitory effect of 2,4-D on salt accumulation is suggested by recent work with azide. Spiegelman, Kamen, and Sussman (9) studied the inhibition of anaerobic synthesis in yeast by

TABLE 6

		Oxygen consumption, mm ³ /hr/45 root segments*			
Test No.	Hour after experimental treatment	KNO ₃	KNO ₃ + 2,4-D	2,4-D only	H ₂ O only
1	1st	64.5	64.5	65.8†	64.1†
	7th	54.7	53.1	59.7†	43.2†
	Change	-10.8	-11.4	-6.1	-20.9
2	1st	58.7	61.5	63.4†	53.9†
	5th	62.6	61.5	63.5†	39.4†
	Change	+ 3.9	0.0	+ 0.1	-14.5
3	1st 3 hrs	49.9†	...	47.3	45.9
	5th	56.8†	...	52.2	44.7
	Change	+ 6.9	...	+ 4.9	- 1.2

* KNO₃, 0.0025 M; 2,4-D, Test 1, 5 ppm; Test 2 and 3, 10 ppm.

† Only one vessel in each experiment for these treatments; other rates are average values for two vessels.

azide. These investigators suggest that azide uncouples anaerobic oxidation of carbohydrate from synthesis by a replacement reaction which prevents the formation of adenosine triphosphate. The suggestion that an uncoupling of oxidation and phosphorylation may likewise be involved in the 2,4-D inhibition of salt accumulation is supported by the observation that oxygen consumption of the roots is not diminished even though the accumulation is inhibited by 2,4-D.

References

- BROWN, J. W. *Bot. Gaz.*, 1946, **107**, 332.
- HSUEH, Y. L., and LOU, C. H. *Science*, 1947, **105**, 283.
- LUNDEGARDH, H. *Annu. Rev. Biochem.*, 1947, **16**, 503.
- MACHLIS, L. *Amer. J. Bot.*, 1944, **31**, 183.
- MITCHELL, J. W., and BROWN, J. W. *Bot. Gaz.*, 1943, **107**, 120.
- NANCE, J. F. *Amer. J. Bot.*, in press.
- RASMUSSEN, L. W. *Plant Physiol.*, 1947, **22**, 377.
- SMITH, F. G. *Plant Physiol.*, 1948, **23**, 70.
- SPIEGELMAN, S., KAMEN, M. D., and SUSSMAN, M. *Arch. Biochem.*, 1948, **18**, 409.
- TAYLOR, D. L. *Bot. Gaz.*, 1947, **109**, 162.
- WILLARD, H. H., and FURMAN, N. H. *Elementary quantitative analysis*. New York: D. Van Nostrand, 1933.
- WORTH, W. A., and MCCABE, A. M. *Science*, 1948, **100**, 16.

Comments and Communications

Directory of Latin-American Scientific Institutions

During the eight years that the Committee on Inter-American Scientific Publications has been in operation a large amount of information has been accumulated on the academies, universities, scientific societies, and other scientific institutions, both private and governmental, for all of the Latin-American countries. The readers of *Science* may be interested to know that with the aid of a small grant from the Pan-American Union this material is now being assembled into a Directory, which will be available in printed form later this year. We have had the assistance of prominent scientists as editorial advisers in each country; consequently, it has been possible to report in considerable detail on the structure of the faculties of the leading universities.

A report on the history and general activities of the Inter-American Committee is in preparation.

HARLOW SHAPLEY, *Chairman*, and

CHRISTINA BUECHNER, *Executive Secretary*

15 Newbury Street, Boston, Massachusetts

Direct-writing Instruments for Radiocardiography

In Prinzmetal's article on radiocardiography (*Science*, September 24, 1948, p. 340) mention is made of a direct-writing counter used in this work; however, there is no description of the apparatus per se. In no article, nor in conversation with members of the Instrumentation Branch of the AEC, have we been able to find adequate descriptions of such apparatus.

We have devised direct-writing instruments that are very suitable for this work and are only adaptations of standard laboratory instruments. Anyone interested in radiocardiography may in this short note find some helpful hints for his own use.

Any counting-rate meter type monitoring instrument can probably be used in direct-writing counters. In our laboratory the Victoreen model 263A has been adapted because it happened to be on hand. All that is necessary is that leads be attached to each side of the meter. These leads are then attached to a linear potentiometer, and a portion of the voltage across the potentiometer is fed to the ink-writing or photographing instrument used. We have fed a portion of this voltage into a portable electrocardiograph and into a visocardiometer, obtaining excellent tracings. The only precautions necessary are that the potentiometer have high impedance in proportion to the meter of the monitoring instrument so that most of the current flows through the meter (we use a ratio of approximately 1000:1) and that only a fraction of the voltage across the potentiometer be used to acti-

vate the ECG string or wire. The response of the ECG is linearly proportional to the meter of the monitor over the whole meter range. The moderate sensitivity range of the monitor is best for use with all writing instruments we have used.

We have recently used the same monitor in conjunction with a standard d-c amplifier and ink-writing oscillograph. In this case the leads were set directly into the amplifier input without interposition of the potentiometer. Again the moderate sensitivity range was most desirable. Response of the pen was certainly adequate. Slow speed on the paper feed gave best results.

Any such setup as has been described has some of the following advantages: (1) availability of the parts used; (2) easy adaptability of the instruments; and (3) the use of multichannel ECG machines and ink-writing oscillographs, which allows simultaneous determination of results with variation in placement of GM tubes over the precordium and with simultaneous standard ECG records using one pair of leads to the multichannel instrument. (The multichannel oscilloscope needs a pre-amplifier ahead of one d-c amplifier to allow ECG's to be made.)

CAPT. PAYNE S. HARRIS

Army Medical Department Research and Graduate School, Army Medical Center, Washington, D. C.

The Highest Laboratory in the World

In the November 5, 1948, issue of *Science*, under News and Notes (p. 498) the following statement appeared.

"The highest laboratory in the world, situated on the summit of Mt. Evans, Colorado, at an elevation of 14,156 feet, is currently being used. . . ."

I thought it would be of interest to the readers of *Science* to mention that the highest laboratory in the world is located in Morococha, Peru (a mining town of about 4,000 inhabitants) at an altitude of 14,900 feet. This laboratory belongs to the Institute of Andean Biology, Faculty of Medicine of Lima, and it is used for physiological and clinical investigations relating to the influence of a low pressure environment. At the present time a new and larger building is being completed.

ALBERTO HURTADO¹

Faculty of Medicine, Lima, Peru

A Suggested Contraction for "Desoxyribonucleic Acid"

I have listened to numerous lectures in which the speaker mouthed the 10-syllabled "desoxyribonucleic acid" from 5 to 25 times. Such terms as "dopa" and "paba" are in common use by scientists. Why, then, could we not designate this important nuclear constituent by the simple and euphonious contraction "dorna?"

RUTH S. BITTER

Bacteriology Laboratory, Hospital Division, Medical College of Virginia

¹ Now visiting medical centers in this country at the invitation of The Rockefeller Foundation.

NEWS and Notes

Charles F. Kettering, a co-sponsor of the Sloan-Kettering Institute for Cancer Research since 1943, has been named the chairman of the 1949 fund-raising campaign of the American Cancer Society, for which a minimum goal of \$14,500,000 has been set. The drive is scheduled for April.

Robert Fross Rinehart, director of the Planning Division of the Research and Development Board since last July, has been appointed executive secretary of the Board, to succeed **Lawrence R. Hafstad**.

Parker R. Beamer, Department of Pathology at Washington University Medical School, has been appointed professor of microbiology and immunology and associate professor of pathology at the Bowman Gray School of Medicine, Wake Forest College, effective July 1.

Leon Campbell, Pickering Memorial Astronomer at the Harvard College Observatory, was the guest of honor at a dinner held in Cambridge January 29 and attended by 125 of his colleagues. In recognition of his 50 years' service to astronomy, he was presented an illuminated scroll by Donald H. Menzel, associate director for solar research in the Observatory.

W. R. Hatch has been appointed chairman of the Division of Biological Sciences at the State College of Washington, Pullman. He is succeeded by **Noe Higinbotham** as chairman of the Department of Botany.

Jack R. Ewalt, director of the Galveston State Psychopathic Hospital of the University of Texas Medical Branch, has been made administrator of the Medical Branch Hospitals, succeeding **B. I. Burns**, who has become head of the Municipal Hospitals in Kansas City, Missouri.

Adriance S. Foster, professor of botany at the University of California, has returned to the Berkeley campus

from a 6-month trip to South America with an extensive collection of tropical plants from the Amazon jungle. The object of his trip, for which he was awarded a Guggenheim fellowship, was to make a general study of the morphology and anatomy of certain groups of tropical plants. He was a guest investigator at the Instituto Agronomico do Norte in Brazil while working at Belém, near the mouth of the Amazon.

Vincent Salmon, former staff physicist for Jensen Manufacturing Company, Chicago, will head the sonics section of Stanford Research Institute's Physics Research Department. Dr. Salmon will continue his studies on industrial applications of high frequency sound and investigate the relationship of sonics to underwater and aerial acoustics.

Theodora L. Coolis, zoology teaching assistant at the University of Wisconsin for the past two years, was recently appointed biology instructor at Kalamazoo College, Michigan.

Paul F. Shope has been appointed associate professor in the Department of Botany and Plant Pathology of the Oklahoma Agricultural and Mechanical College.

John F. Fulton, Sterling professor of physiology at Yale University School of Medicine, will deliver the 6th Frank Billings Lecture at a joint meeting of the Institute of Medicine of Chicago and the Society of Medical History of Chicago on February 25. His subject, commemorating the centennial of the birth of William Osler, will be "Osler as a Humanist."

Henry P. Kalmus, formerly at Zenith Radio Corporation's research laboratory, has been appointed to the staff of the National Bureau of Standards. He will conduct investigations in advanced electronic techniques in the Bureau's Ordnance Research Laboratory.

Robert W. Wood, Johns Hopkins physicist, was made honorary Doctor of Science by Oxford University when he was in England last October.

Visitors to U. S.

Sir Harold Spencer Jones, Astronomer Royal of England, arrived Feb.

7 to begin a 3-month lecture tour of the U. S. His host is S. A. Mitchell of the Leander McCormick Observatory, University of Virginia.

Godfrey S. Delatour, former staff member of the Universities of Berlin, Frankfurt, and Paris, has been named visiting lecturer in the University of Illinois Department of Sociology and Anthropology. Prior to his recent appointment, Dr. Delatour lectured at Columbia University.

Colin White, formerly a lecturer at the University of Birmingham, England, recently accepted a 2-year appointment as assistant professor of physiology in the School of Medicine, University of Pennsylvania. Dr. White's appointment was made with a view to promoting the exchange of teaching and research ideas between the U. S. and other countries.

Grants and Awards

Great Britain's Royal Photographic Society has awarded its 1948 Progress Medal to Loyd A. Jones, head of Kodak Research Laboratories physics department. Dr. Jones received the honor for his contribution to the use of photographic sensitometry in the manufacture and control of photographic materials. He will go to England in May to deliver the Hurter and Driffield Lecture before the Society.

The University of California at Berkeley has been granted \$100,000 by the Rockefeller Foundation for equipping the new **Virus Laboratory**, headed by Wendell Stanley, Nobel Laureate who recently joined the faculty. The funds will be available for the three-year period 1949-51. A \$15,000 ultracentrifuge is already in use at the laboratory and an electron microscope will be added soon.

Applications for grants from the **Cyrus M. Warren Fund of the American Academy of Arts and Sciences** should be received by the chairman of the Committee, Frederick G. Keyes, Massachusetts Institute of Technology, not later than April 30. Grants are made in aid of chemical research—generally for apparatus or supplies, or for the construction of special facilities needed for research in chemistry or closely related fields. Be-

cause of limited resources, the amount to an individual is seldom more than \$300. Application blanks may be obtained from the chairman.

The Robert Gould Research Foundation of Cincinnati has made a grant-in-aid of \$5,000 to The Johns Hopkins University for research in 1949 by E. V. McCollum, professor emeritus of biochemistry, School of Hygiene and Public Health of the University. The fund will enable Dr. McCollum to continue his study of the chemistry of nutrition, particularly the problem of separating amino acids in pure form.

Fellowships

A fellowship in obstetric and gynecologic endocrinology is offered to qualified M.D.'s for work under A. E. Rakoff at the Jefferson Medical College and Hospital. Applicants for the fellowship, which will be available about May 1, 1949, should communicate immediately with Lewis C. Scheffey, Professor of Obstetrics and Gynecology, Head of Department, and Director of Division of Gynecology, Jefferson Medical College and Hospital, Philadelphia 7.

The New York State Department of Health is offering fellowships of \$3,600 per year for the training of physicians to qualify for public health positions in the state. The training, for one year or more, is for health officers, tuberculosis physicians, clinical consultants, and laboratory directors. Further information and application forms are obtainable from Franklyn B. Amos, Director of the Office of Professional Training, New York State Health Department, Gov. Alfred E. Smith State Office Building, Albany 1.

Colleges and Universities

The University of Massachusetts has inaugurated an instruction and research program in physiological and chemical aspects of radioactivity. In connection with the safety program, Austin M. Brues, of the Argonne National Laboratory, recently lectured on "Biological Consequences of Radioactivity." The research program, which is aided by the National Research Council's Committee on Material Health, is already under way. It

involves problems of radioactive phosphorus transfer in relation to sperm metabolism.

Members of the Johns Hopkins University faculty present a televised program each Friday night at 9:00 over the Columbia Broadcasting System network. The series, called "The Johns Hopkins Science Review," offers demonstrations of basic principles in various fields of science and illustrates work being done in the Hopkins research laboratories. The February programs are on insect repellents, art applied to medicine, the human heart, and supersonic flight. Televiewers are invited to send in topics which they would like to see presented.

Frontiers in Chemistry, the 8th annual lecture series of Western Reserve University will be held in Cleveland beginning March 4. The first group of 5 lectures on "Recent Advances in Physical and Inorganic Chemistry" will be given on successive Fridays March 4-April 1 in Room 27 of the Adelbert College Main Building. The second group of 5 lectures will also be held on Fridays—April 15-May 13. Each speaker will present two related lectures, one from 5:15 to 6:05 p.m. and the other from 7:45 to 8:35 p.m. Admission fee to each group of lectures is \$10.00. Tickets for individual lectures will not be sold. Approximately 200 tickets are available for each group. They may be purchased at the lecture room on opening night or from the University Registrar, Western Reserve University, 11105 Euclid Avenue, Cleveland 6, Ohio.

Summer Programs

Purdue University announces its second annual Short Course for Mold Technicians to be held July 11-23 on the University campus. The course, under the direction of C. L. Porter, professor of botany, will include the study of mold manipulation and identification, and physiology of fungi. The fee will be \$100, including supplies. Further information may be obtained by writing to M. M. McClure, Division of Technical Extension, Purdue University, Lafayette, Indiana.

The University of Pittsburgh Chemistry Department will give sum-

mer courses, June 7-August 20, in inorganic, analytical, organic, and physical chemistry, carrying 8 semester credits, the equivalent of a full year's work. If there is sufficient demand, a course in biochemistry may also be given. Students may register for the 4-week (one-semester) or for the 8-week (full-year) work. "The Chemical Elements and Their Compounds," a continuation of last summer's course on "Fundamentals of General Chemistry for Teachers," will be held June 27-August 6. This course carries 2 credits. For further information, write Alexander Silverman, Department of Chemistry, University of Pittsburgh, Pittsburgh 13, Pennsylvania.

Meetings and Elections

The Torrey Botanical Club recently elected the following officers for 1949: president, Edwin B. Matzke, Columbia University; 1st vice president, Charles A. Berger, Fordham University; 2nd vice president, Marion A. Johnson, Rutgers University; corresponding secretary, Jennie L. S. Simpson, Hunter College; recording secretary, Donald P. Rogers, New York Botanical Garden; treasurer, Elva Lawton, Hunter College; editor, Harold W. Rickett, New York Botanical Garden; business manager, Harold H. Clum, Hunter College.

The American Mathematical Society will hold its 443rd meeting on February 26 in the Pupin Physics Laboratory, Columbia University, New York City. The Society's 444th meeting will be held on the same date in Eckhart Hall, University of Chicago, Chicago. The 445th meeting will take place April 1-2 at Duke University, Durham, North Carolina.

An International Conference on Science Abstracting is being convened by Unesco, to meet at Unesco House in Paris June 20-25, 1949. A working paper for the conference is in preparation by Thérèse Grivet, making use of the analytical survey of abstracting services prepared for Unesco by the International Federation for Documentation at the Hague.

In addition to the voting representatives from the United Nations Member States, there will be repre-

representatives from many international organizations having special interest in science documentation. Not only representatives of abstracting services but also working scientists, science librarians and documentalists will be invited. Observers are welcome.

The conference will receive and discuss a report on the present state of science abstracting, explore alternative abstracting techniques, and discuss such problems as language difficulties and means for improving the accessibility of publications (inter-library loans, photocopying, etc.). It will also make proposals for improving abstracting service through standardized bibliographies, terminology, and layout, and through greater cooperation among services by subject and language to effect economies and eliminate gaps.

Further information on the conference may be had by writing J. B. Reid, Program Specialist for Scientific Literature, Unesco, 19, Avenue Kléber, Paris 16.

Michigan State College will hold its annual **Dairy and Food Inspectors School** April 4-7. Those interested may obtain full details of the School and a copy of the program from W. L. Mallmann, Department of Bacteriology and Public Health, Michigan State College, East Lansing.

BAAS Meeting at Brighton

The 110th meeting of the British Association for the Advancement of Science, held in the southern England seaside town of Brighton in September last, was criticised by many as formless and lacking inspiration. There was some justification for this view when the inevitable comparisons were made with the highly successful previous year's meeting, held in the Scottish University town of Dundee, where there were 1,750 local members as against Brighton's 150, and where there was an exciting theme, "Swords into Ploughshares," whilst Brighton's meeting had none.

Yet there was a certain cohesiveness at Brighton, due entirely to the masterly presidential address of Sir Henry Tizard, F.R.S. The keynote of his words was the great need to increase industrial productivity, and many of

the discussions in the various sections fitted into his lead.

Sir Henry spoke a day after Sir Stafford Cripps, the Chancellor of the Exchequer, had told the powerful Trades Union Congress that Britain needed to use more brain in tackling the problem of productivity. Without referring directly to that speech, Sir Henry (the key figure in Britain in the application of science to social needs, as he was then president of the British Association, and is now chairman of three Government bodies: the Advisory Council on Scientific Policy, the Industrial Productivity Committee, and the Defense Research Policy Committee) proclaimed what "more brain" could do.

Sir Henry made it clear that what was needed was not the general expansion of research—"certainly not the expansion of Government research remote from the everyday problems of industry"—but to apply what was already known. The productivity of labour was far lower than it could be if the results of past research were more resolutely and continuously applied. There was a need, he said, for well-trained management in industry, in which technical efficiency was the concern of engineers and technologists who had intimate contact at all levels with scientists responsible for research and development. In other words, scientific thought and influence should be present in the whole process from research to production and use.

This country needed also to maintain a high standard of teaching in the schools, or the next generation of scientists would suffer. In the long run—Sir Henry went on—the expansion of research would fail to produce the hoped-for result unless education in the higher branches of technology was promoted. Finally, he drew attention to the social problems of great complexity that had arisen from the development of preventive medicine. A growing world population was competing for limited supplies of food, and the numbers reaching the sixth and seventh decades of life was growing greatly. He believed that whatever new comforts and luxuries might be provided in future by the advance of physical science, it was on the development of the biological sci-

ences that the peace and prosperity of the world would depend largely.

On the next day, in his presidential address to the Economics Section, Sir Hubert Henderson rebuked economists who were among "the most extravagant propagandists of go-easy illusions, the most pushing salemen of 'servating fools' paradises," for not appreciating the magnitude of the effort required by Britain to surmount her economic difficulties. In present conditions, he said, controls were useful and sometimes indispensable.

Another economist, Mr. S. R. Dennison, declared, however, that it was exaggeration to say that almost everything—the effects of the war years, the lack of incentive in inflation conditions, the effect of direct taxation on incentive, and the seller's market for labour, for example—except official exhortation, was directed towards encouraging a slow working pace. The chief cure, then, was to create conditions which encouraged increased effort. There were no simple formulae of technology or organisation which could take its place. The confusion of thought on productivity was, he believed, a factor contributing to the misdirection and waste of resources which were the distinguishing mark of the present situation.

The psychologists agreed that there was a need to create conditions which encouraged increased effort: but their approach was different from that of Mr. Dennison. "The dominating factor in this matter of incentives," said Mr. Nigel Balchin, "is that our old purely financial concepts are bankrupt; that in our world today the nature of incentives is nothing more than the nature of human motivation, that 'workers' are nothing less than the human race, and that 'work' is and must be nothing less than life. It is as simple as that and we cannot avoid the tremendous implications of that simplicity."

He was reinforced by Mr. Adam Curle, who believed we had "to consider the structure and orientation of society rather than specific goals whose impetus will not long outlast, in our adverse environment, their application." And by Professor C. A. Macleod who declared there was no very short term policy which offered a promise of meeting the present demand for

stronger "will to work." The foundation of a satisfactory incentive system lay in vocational guidance, vocational education, and the organization of a social and industrial order in which cooperation sprang from purposes genuinely shared by those who needed to cooperate.

The problem of productivity is not one that concerns industry alone. It is important also in agriculture: for, as Dr. G. Scott Robertson pointed out, the world is once more facing the problem of want with the passing of the period of plenty. The world's population is increasing by 20,000,000 per annum, and we are pledged to raise the standard of living of backward countries.

Although the situation was grave, Dr. Robertson was not pessimistic. If a peaceful world were to set itself the task of applying the knowledge already have in preventing soil wastage by erosion, in increasing production by irrigation, by the application of the exacting knowledge of plant breeding, by application of fertilisers, by the mechanisation of work on the land, not forgetting the electrification of the farm buildings and homes, and by developing rapidly the application of genetical science to the breeding of our farm animals the world over, it would, at a very conservative estimate, be possible to double and even treble our production of food in a relatively short time." The effective application of existing knowledge in Britain and the U.S.A. would raise agricultural output by at least 50 percent.

It was also necessary to cut down the gigantic losses due to the diseases of crops and stocks and the depredation of pests, and insects. Between harvest and consumption there is destroyed every year, by mites, pests and rodents, grain equivalent to all the food traveling into international trade—about 65,000,000 tons.

Sir John Russell, F.R.S., underlined these words by pointing out that while population was steadily increasing, the area of agricultural land was steadily diminishing. "We need a new type of agricultural research," he said, "corresponding to the operational research of large-scale industry. It will be necessary to study closely the methods of the best farmers (who hold

more than half the total number of farms and nearly two-thirds of the land). A detailed study of these successful enterprises should show the principles underlying their success and open the way to some advance comparable with that from the three-field system to the Norfolk rotation."

Reports were given by two geneticists—Mr. Gordon Haskell and Mr. H. P. Donald—on inbreeding and hybrid vigour in crop improvement and livestock production. Inbred strains of corn hybridised together produced offspring showing increased vigour, such hybrids often surpassing both parental varieties in yielding capacity. In the U.S.A. 62,000,000 acres out of 90,000,000 under maize were sown with hybrid corn (or maize). The hybrid seed was being introduced into Europe, with good results. The same technique was being used for chickens, with great success.

Dr. Michael Graham described how mathematical theory was being applied to fishing, allowing the proper application of data of fishery research, so as to calculate the yield of a fishery under various rates of fishing and other conditions. One formula had been used with success to forecast certain catches for the past three years.

A grave warning was given by Professor J. D. Bernal, F.R.S., that the extremely rapid increase in the utilisation of materials of all kinds in industry and agriculture was beginning to be on such a scale that it affected the actual available supply of many of the elements and threatened to exhaust their most concentrated deposits in a matter of decades. He described how in an industrial system elements did not remain in any fixed place, but underwent a cycle in which they were combined in different ways with other elements, and where they were concentrated, dispersed, and again concentrated.

A careful examination was needed of every phase of the utilisation cycle in conjunction with that of the whole industrial process, with particular regard to the possibilities of research in making processes, especially the recovery process, economic. The most important new idea, essential to any effective utilisation of the elements, was that no element should be employed where its particular properties

were not utilised to the full. One way of ensuring such economic use of elements was by the extension of functional specification to the widest number of cases, that is, not a specification for the use of a certain element, but a specification of the fabrication of a product with such and such physical or chemical properties.

Conservation of manpower was a feature of the discussion of the problems of old age. Describing the aged as "a new reservoir of productive power for the nation," Sir Ernest Rock Carling denied that there was any warrant for persons to retire at 60 or 65. This was dictated on sociological, and not on biological, grounds. The number of healthy and independent old people (6,000,000) completely overtopped the ailing, the sick, and the decrepit (200,000). The disabilities of age could be offset by intelligent adaptation: and at work the old showed less psychological weakness than the young, and were a good steadying factor. To help the individual in ill health, it was not drugs that were needed, but personal effort, bodily and mental activity, occupation, and interest.

Much attention was paid to the role of the colonies in helping Britain to meet her food problems. The geographer here made a special claim for full use of his abilities. "For our own good name," said Lord Rennell of Rodd, "the social geographer must be called in to play his very large part in adapting our changing conceptions of African administration, and in seeking to rationalize the mess which western European nations, including ourselves, have made in the African continent." Many other significant aspects of the Commonwealth were discussed—such as the problem of emigration from Britain and the urgent need for a colonial atlas.

There was much misgiving about the training of the scientist and of the young worker in industry. Professor John Reed, F.R.S., in a delightful paper on Specialisation and Culture in Chemistry, showed how bad were the consequences of specialisation. His words have a general application. "We ought at least to take what steps we can to combat the narrowing outlook which now threatens to affect science students at all levels," he said,

"and we ought particularly to bear in mind their social, cultural and spiritual needs." He ended with the words: "Ending as we began, upon an alchemical note, we realize that the microcosm of man has its roots and being in the macrocosm of the outer world, with which it is one. As Salomon Trismosin wrote in the heyday of alchemy:

Study now whereof thou'rt part;
So shalt thou see of what thou art;
What thou studieth, learn'st and art,
Of that it is thou formest part.
All that is around without us
Is eke within us. Amen."

On the needs of youth in industry, Mr. F. Bray was outspoken. "What is wanted at the moment," he declared, "is better accommodation, more up-to-date equipment, more good teachers, good libraries, and good social amenities—indeed all those things which encourage students to make themselves efficient workers and good citizens."

In reviewing this meeting for "The Times" of London, I concluded: "All in all, in spite of the proper absence of a single set theme at the Brighton meeting, it has been made clear that workers in nearly every field of the advancement of science have been turning attention, like Sir Henry Tizard, to the contribution which they can make to remedying the world's material troubles. Yet, at the same time, it has been made equally clear that science goes forward, as it must always go forward, in pursuit of the truth wherever it may lead, and among the chief memories of the Brighton Conference will be such notable events as Sir Lawrence Bragg's classic presidential address to the mathematics and physics section on Recent Advances in the Study of the Crystalline State.

This year the British Association is to hold its meeting in Newcastle, in the North Country. The president is Sir John Russell; and the presidents of the various sections are: Sir Harold Spencer Jones (Physics and Mathematics), Sir Alfred Egerton (Chemistry), Professor W. J. Pugh (Geology), Professor A. C. Hardy (Zoology), Professor L. Dudley Stamp (Geography), Sir Alexander Gray (Economics), Sir Arthur Fleming (Engineering), Mr. M. C. Burkitt (Anthropology and Archaeology), Professor R. A. Peters (Physiology), Professor G. H. Thom-

son (Psychology), Professor Lily Newton (Botany), Sir F. Clarke (Education), Professor N. M. Comber (Agriculture). MAURICE GOLDSMITH

Deaths

W. D. MacMillan, 77, professor emeritus of astronomy and mathematics, University of Chicago, died November 14.

W. S. Hall, 87, professor emeritus of mathematics at Lafayette College and charter member of the Mathematical Association of America, died December 17.

Vincent H. Morris, 50, chemist-in-charge of the Federal Soft Wheat Laboratory at the Ohio Agricultural Experiment Station, Wooster, died January 17 at Wooster, Ohio.

John E. Weeks, 95, author and professor emeritus of ophthalmology at New York University, died February 2 while vacationing in La Jolla, California. Co-discoverer with Robert Koch of the Koch-Weeks bacillus, Dr. Weeks received the Ophthalmological Research Medal of the American Medical Association in 1929.

Rudolf Samuel, 52, author and professor of physical chemistry at the Haifa Technical College, died in Tel Aviv February 3.

Hans Wollenweber, 69, German plant pathologist, died February 3 in Washington, D. C. Dr. Wollenweber, who had worked in the U. S. Department of Agriculture for several years, came to the U. S. last fall, planning to become an American citizen and continue his research work here.

Henry V. Gummere, 78, emeritus lecturer in astronomy at Haverford College, died February 9 at his Philadelphia home.

A joint U. S.—Australian expedition, sponsored by the National Geographic Society, the Smithsonian Institution, and the Commonwealth of Australia, has recently returned from Arnhem Land, the Stone Age country of northern Australia. The naturalists spent 8 months there (see *Science*, February 20, 1948, p. 190) and brought back a collection of more than 10,000 fish, 350 birds, and 460 mammals—

some of them previously undescribed. They also learned much about the customs and relics of the natives. One of the most significant archeological discoveries of the expedition was the complete Stone Age hatchet unearthed by Frank M. Setzler, Smithsonian anthropologist. Countless pieces of chipped quartzite, shaped to a cutting edge, had been found previously in many parts of eastern Australia, as well as Arnhem Land. The discovery of the hatchet—one of the scrapers attached by cement to a handle—established conclusively the use of this tool by the early Australian aborigines.

A new laboratory for studying range-finder performance has been established at the National Bureau of Standards with the cooperation of the Army Ordnance Department. It is under the direction of I. C. Gardner and is equipped with a temperature-controlled test chamber and an optical range finder that simulates a target for eight different ranges under conditions corresponding to a wide range of climate. The new laboratory permits a systematic analysis of the various components of the error of a given range finder and has thus been useful in suggesting improvements in design.

The Naval Ordnance Laboratory's new central unit at White Oak, Maryland, was recently dedicated and is now an integral part of the \$35,000,000 project for research in modern armament. Begun during the war, the Laboratory now utilizes 60-odd permanent buildings as well as 34 temporary structures, and has 9 more permanent buildings under construction.

The AAAS Membership Office, 1515 Massachusetts Avenue, NW, Washington 5, D. C., will appreciate any information concerning the present addresses of the following people, all life members, whose names and last known addresses are as follows: A. W. Elliott, New York City; Mary L. Jackson, Pittsburgh; Fred I. Lackenbach, San Francisco; J. D. Marmor, New York City; Shigeo Yamanouchi, University of Chicago.